POWER

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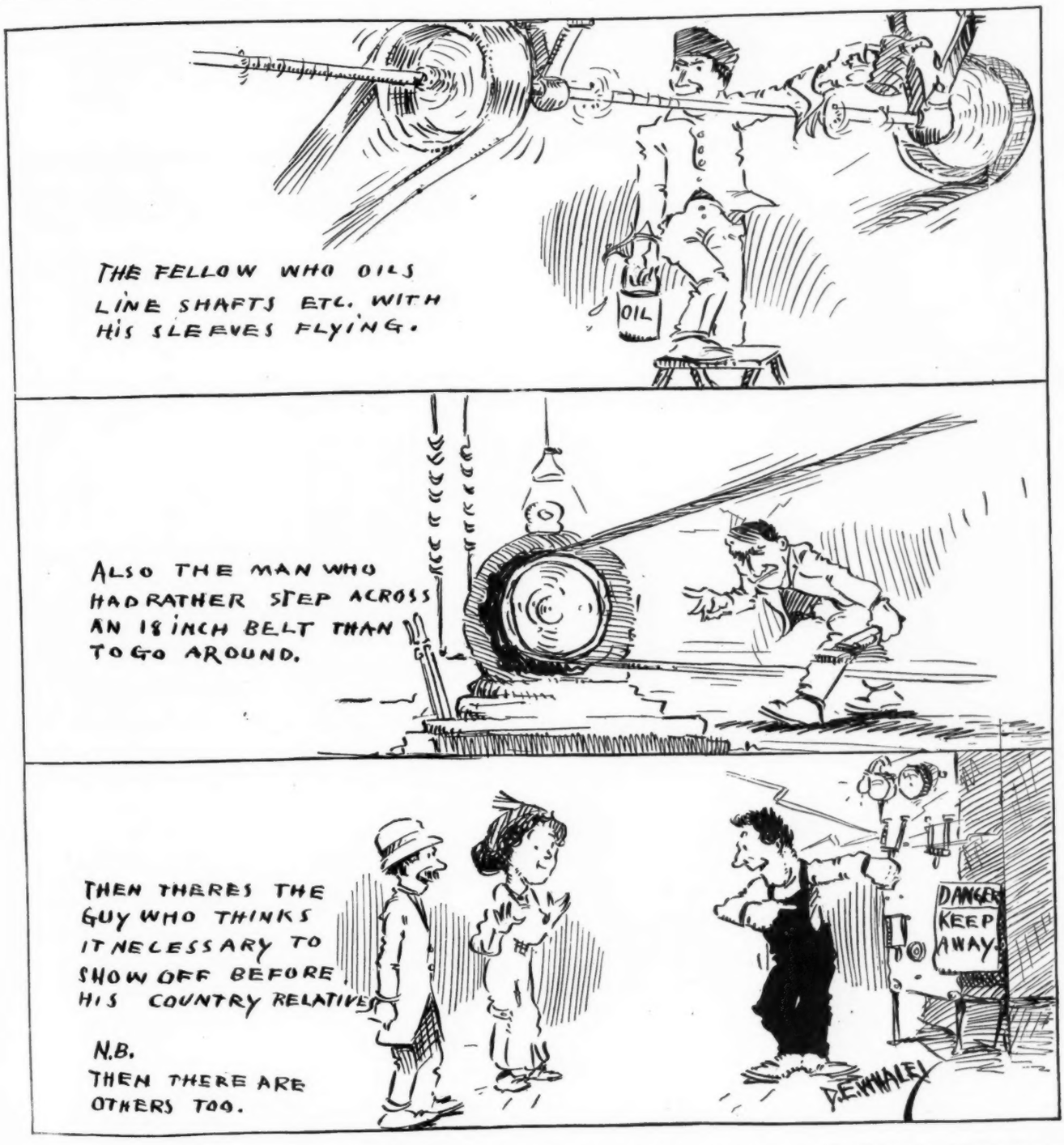

THE FELLOW WHO OILS LINE SHAFTS ETC. WITH HIS SLEEVES FLYING.
OIL
ALSO THE MAN WHO HAD RATHER STEP ACROSS AN 18 INCH BELT THAN TO GO AROUND.
THEN THERES THE GUY WHO THINKS IT NECESSARY TO SHOW OFF BEFORE HIS COUNTRY RELATIVES
N.B. THEN THERE ARE OTHERS TOO.
DANGER KEEP AWAY
D.E. WHALEY

THREE REASONS WHY SOME INSURANCE COMPANIES CONSIDER ENGINEERS A POOR RISK

Jacksonville Municipal Power Plant

By C. C. Austin

SYNOPSIS—An uptodate municipal turbine power plant of 6000-kw. capacity. Fuel oil is used in the boiler furnaces. A feature is the construction of the condenser intake water conduits which are used as a foundation for the dividing wall between the turbine and boiler rooms.

Jacksonville, Fla., boasts of one of the best equipped and most uptodate municipal power plants of its size in the United States. The old plant near the center of the city became inadequate to meet the increasing demands and could not be enlarged materially on account of the scarcity of condenser-cooling water, and also because it shared the available space with the city water plant. It was, therefore, decided to move the power plant to a site where there would be an abundance of cooling water and ground area and to leave the old site and buildings entirely to the water-pumping station.

The new plant is about four miles from the center of the city on the banks of the St. Johns River. Texas oil is used as fuel and is shipped by boat to the plant of the Gulf Refining Co., which is near the power plant; the oil is piped from there to the city tanks. If coal is ever used as fuel, it can be transported much of the distance from the mines by water. Plant supplies can also be shipped by water. Fig. 1 is a view of the plant. The bulkhead will be filled in and used as a storage yard for coal, if it is ever used, and as a convenient landing place.

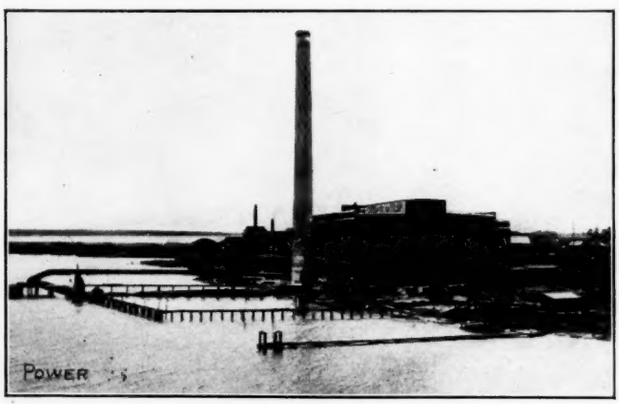


Fig. 1. General View of the Power Plant and Water Front

At present the plant has a capacity of 6000 kw. and the building will admit another 1500-kw. machine. Four 1500-kw. steam-turbine units generate three-phase, 60-cycle, 6600-volt current. Special attention has been paid to securing abundant light and affording every convenience for working around the machines.

An idea of the general arrangement of the apparatus may be obtained from Fig. 3. The nature of the soil and the proximity of the St. Johns River necessitated pile foundations throughout and the intake and discharge conduits have been arranged so as to use their walls as parts of the foundations. The common center wall of the two contiguous and parallel conduits, Fig. 3, forms the foundation for the air and circulating pumps. The outside wall of the intake conduit is of double thickness to provide a foundation for the wall between the boiler and generator rooms. Instead of being side by side, the discharge conduit is mounted on top of the inlet conduit, which permits using a single row of piles to support them both. The hotwell is in the top of the discharge conduit, so built that its overflow drains into the latter.

All of the condensing apparatus is level with the boiler-room floor and below the generator floor. The open space directly above the condensers affords abundant light to inspect the operation of this machinery, except on the darkest days when it will be electrically lighted. Fig. 2 gives a view of this floor.

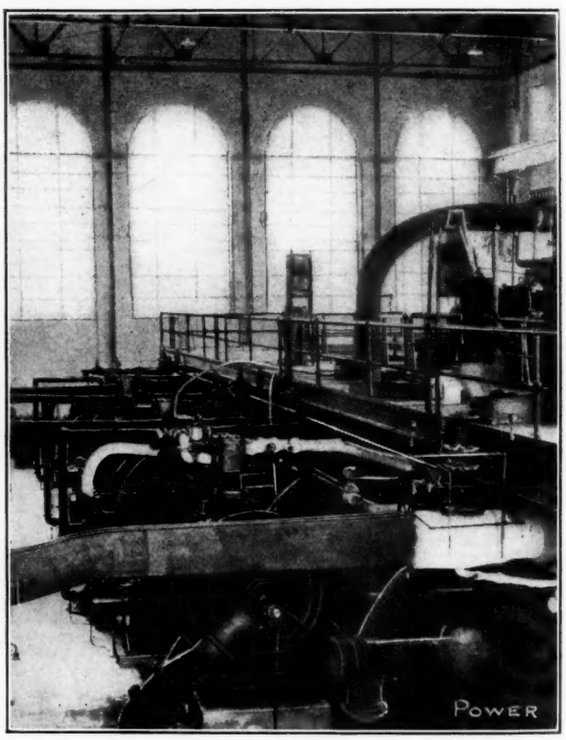


Fig. 2. Air and Circulating Pumps Serving the Condensers

A 30-ton crane of 60-ft. span, having 19 ft. in the clear under the hook, serves the generator room. This crane has a 15-hp. motor for traveling, a 30-hp. hoisting motor, and a 10-hp. motor for the trolley travel. Ten water-tube boilers are installed in batteries of two. Fig. 4 shows part of the boiler room not yet finished. Each boiler has 5200 sq.ft. of heating surface, and a superheater of 660 sq.ft. area. Steam is furnished at 175 lb. pressure and 570 deg. F. Space has been left for two additional boilers. The machine shop of the plant will be in the end of this boiler room.

A brick-lined reinforced-concrete stack, 12 ft., inside diameter, and 201 ft. high, supplies the draft. Its center is 64 ft. from the center of the breeching at the back of the boilers and it receives the gases 29 ft. above its base.

This is one of the few plants in this vicinity that uses oil for fuel. The Texas oil fields are farther from Jacksonville than the Alabama and Tennessee coal mines, but the higher calorific value of the oil, water transportation, low initial cost of burning apparatus, and low boiler-room operating costs gave it a decided preference over coal for this plant. Oil is purchased by contract and pumped to the plant. At the plant 2500 bbl. can be stored and the contract specifies that 5000 bbl. shall be kept in readiness exclusively for this plant. The oil is supplied to the boilers at 60 lb. pressure by a 6 and 5 by 4-in. duplex pump.

Steam Piping

Extra-heavy 12-in. steel piping with Van Stone joints is used in the main steam header with 8-in. piping of the same material from the boilers to the header and from the header to the turbines. Expansion joints were not used anywhere in this line, sweeping pipe bends allow for expansion. The plan of the piping, Fig. 5, shows the numerous bends between the boiler outlet valves and the turbine throttles. The main 12-in. headers are anchored between the 180-deg. bends, but at no other points. This piping system is expensive, but insures continuity of operation at a minimum of operating expense.

In Fig. 6 is shown the turbine exhaust-pipe layout. Any turbine can be run with its own condenser or either condenser of its immediate neighbors, but with no others.

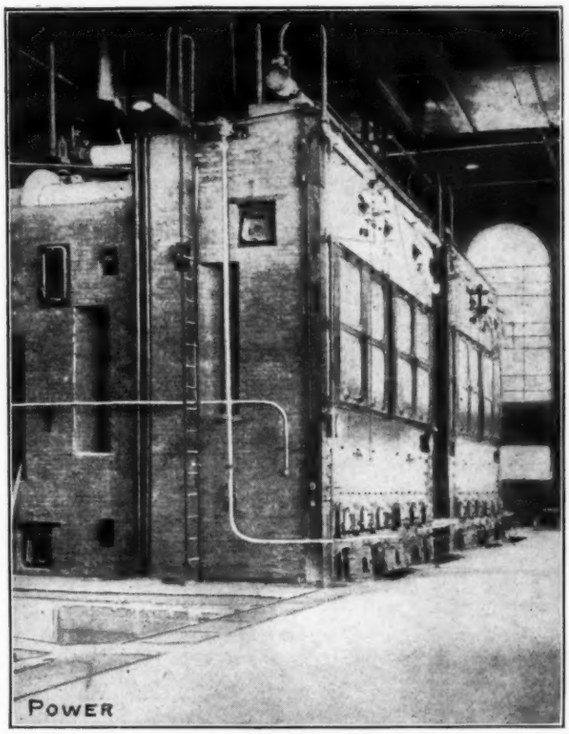


Fig. 4. Boiler Room, Showing Four of the Ten Water-Tube Boilers

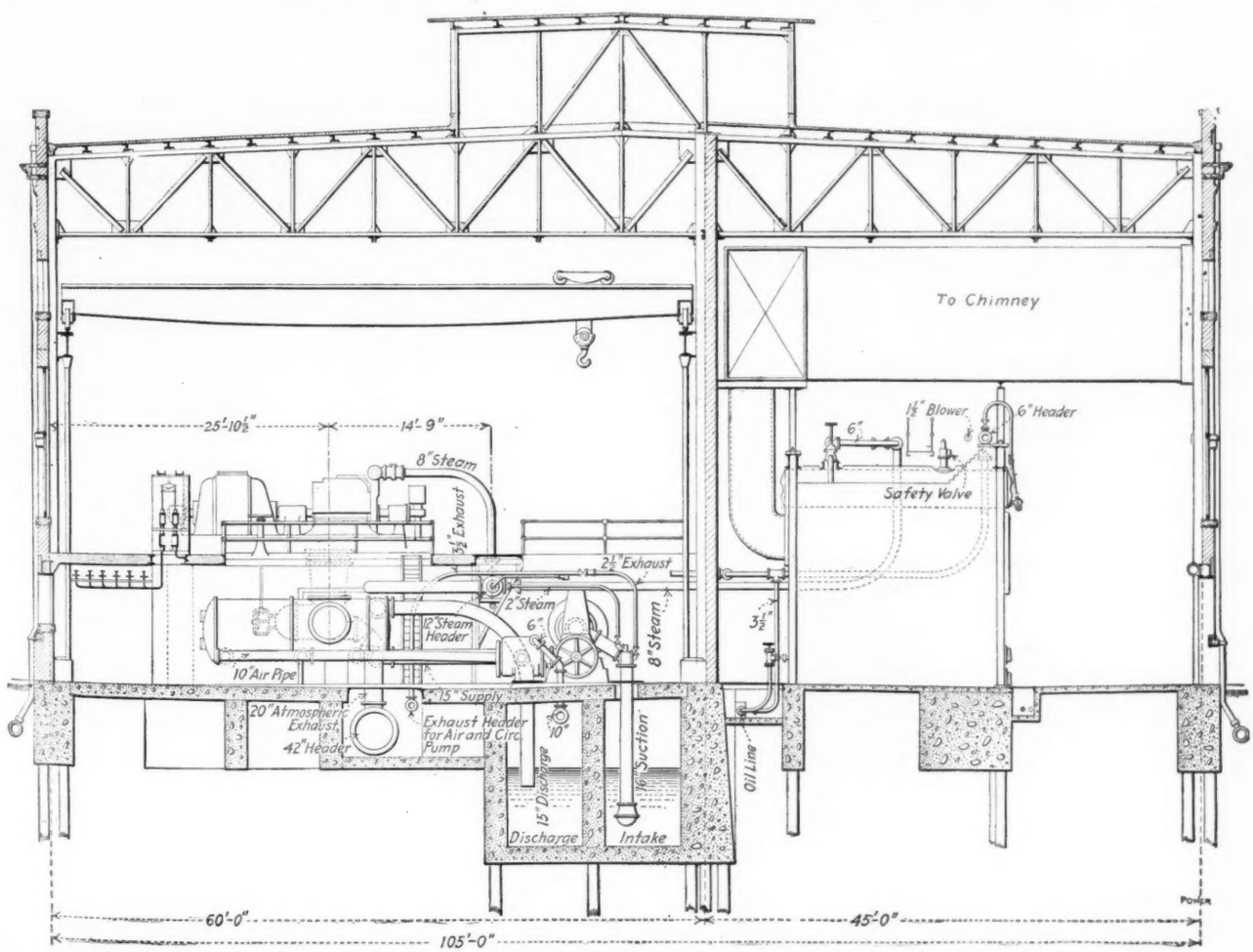


Fig. 3. Elevation of Engine and Boiler Rooms

The remote possibility of all three condensers to which any turbine has access being out of commission does not justify the heavy expense of bypassing the exhaust steam. The valves on the exhaust line between the condensers have bevel-gear operating wheels, to permit operating from the floor of the generator room. These valves will all be motor operated as soon as motors can be installed.

Condensing Apparatus

A 3000-hp. condenser is furnished for each turbine. Circulating water is taken from the inlet conduit at about 62 deg. F. and is pumped by 16-in. centrifugal pumps directly connected to vertical engines. The air pumps discharge into a hotwell. A condensing unit is shown in Fig. 7 in which the condenser proper is shown in the background. The size of the condensing units in proportion to the turbines is sufficient to provide condensing surface for the heaviest peak load which may ever be carried.

Exhaust steam from the condensing units is piped directly to an open feed-water heater and heats the feed water to about 210 deg. An outside-packed 14 and 9 by 18-in. duplex pump feeds the boilers.

A section of the building is devoted to baths, toilet rooms, etc., which equal those found in the best club houses and hotels. The bath rooms are on the first floor; the toilet rooms on the generator-room floor. On the third floor is a reading room where the latest technical journals will be found, and the chief engineer's office is directly behind this room.

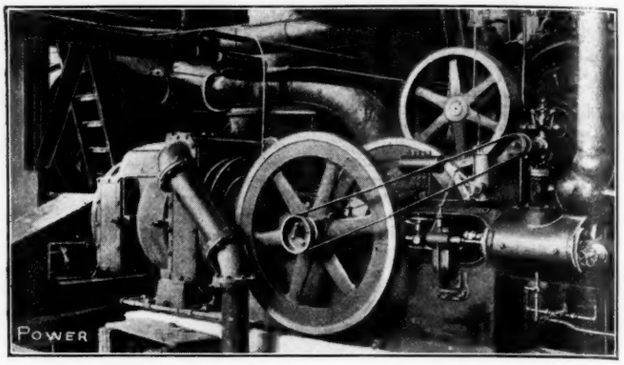


Fig. 7. Condenser Unit

For most of the above data the writer is indebted to the general superintendent, W. H. Tucker, who is responsible for the entire supervision of the plant, substations, distribution, etc. L. E. Murphy, chief engineer, is responsible for the operation of the plant itself.

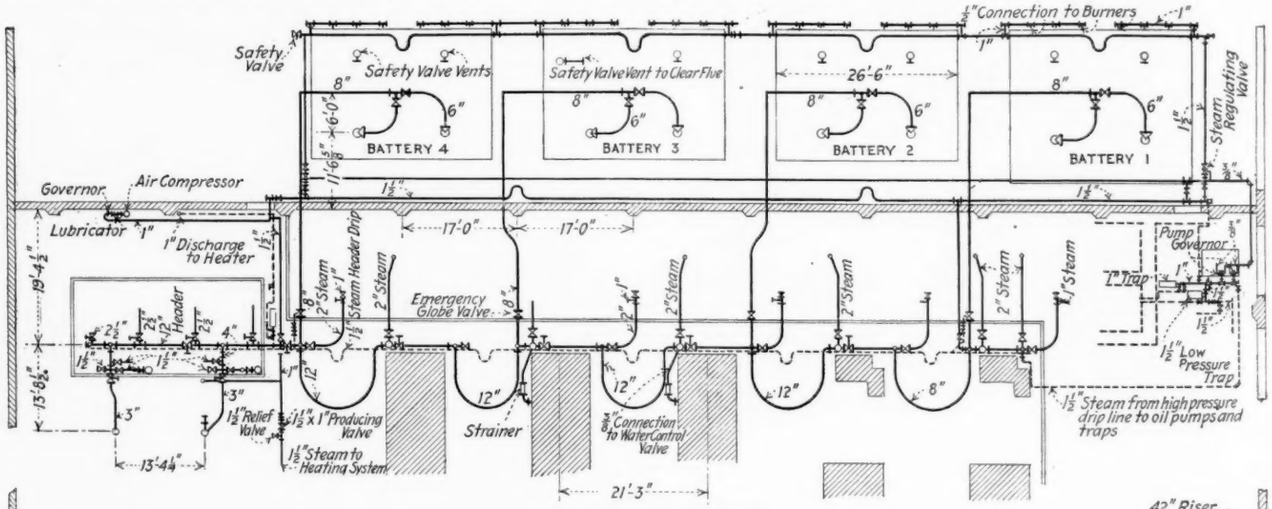


FIG. 5 PLAN OF STEAM LINES

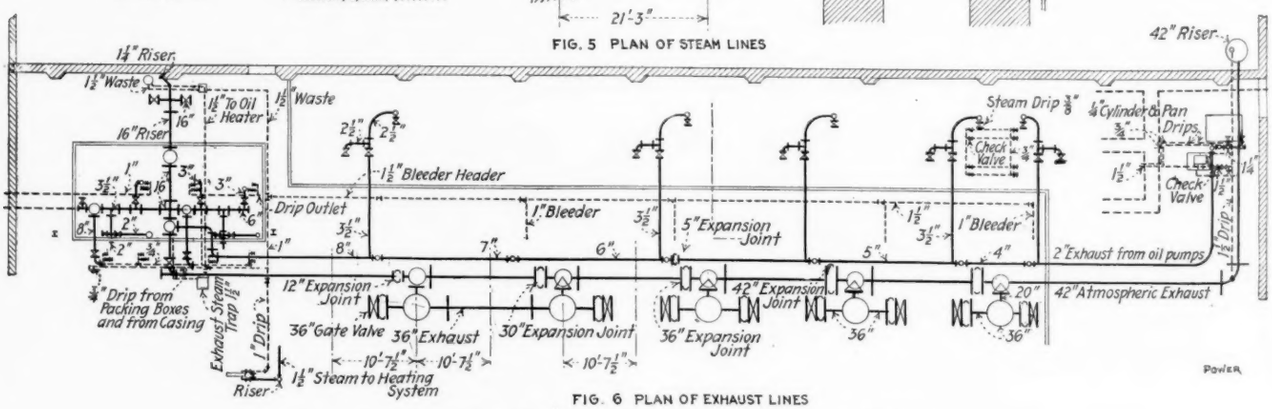


FIG. 6 PLAN OF EXHAUST LINES

Figs. 5 and 6. Plan of Steam and Exhaust Lines

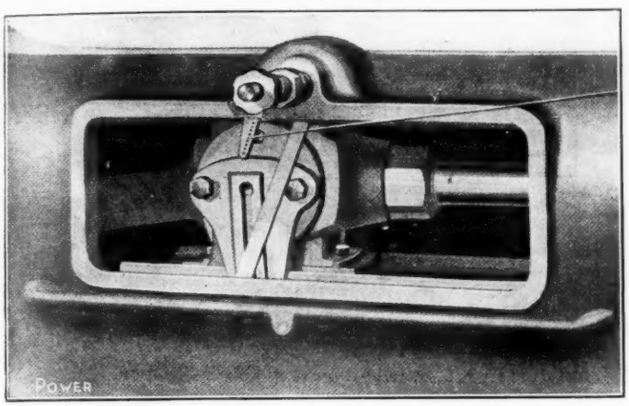
PRINCIPAL EQUIPMENT OF THE JACKSONVILLE, FLA., MUNICIPAL ELECTRIC-LIGHT PLANT

No.	Equipment	Make	Purpose	Kw.	Volts	Phase	Cycles	Size	Hp.	Manufacturers
2	Turbines	Steam	Main units	1500	6600	3	60	.....	....	General Electric Co.
2	Turbines	Steam	Main units	1500	6600	3	60	.....	....	Allis-Chalmers Co.
1	Crane	Power	Gen. room	....	....	....	....	30 ton	....	Niles-Bement-Pond Co.
10	Boilers	Water tube	Steam gen.	....	....	....	....	.....	....	Babcock & Wilcox Co.
1	Chimney	Concrete	Flue gases	....	....	....	....	12x20"	....	Concrete Construction Co.
4	Condensers	Surface	Turbines	....	....	....	....	.....	3000	C. H. Wheeler Mfg. Co.
1	Pump	Duplex	Boiler feed	....	....	.....	..	14x9x18"	....	Warren Steam Pump Co.

Ideal Reducing Motion

The improved "Ideal" indicator reducing motion, which has been developed for use on Ideal Corliss-valve engines, is shown herewith. The mechanism is inside the frame, where it is constantly bathed with oil. The linkage within the frame oscillates a spindle in unison with the piston.

This spindle is mounted on an oil-tight bearing in the engine frame and transmits the movement to the lever outside the frame to which the indicator cord is attached. The lever has a hand-knob and clutch, so that by a slight endwise movement on the spindle, the lever can be instantly engaged or disengaged to start or stop the indicator without disturbing the cord or any other connections.



Ideal Reducing Motion

This reducing motion is made by A. L. Ide & Sons, Springfield, Ill.

Putting Crankpins in Large Engines

By J. N. Lucas

Relative to the method of putting a crankpin in a 5000-hp. engine, as described by W. J. Maxwell in the Feb. 18 issue, page 233, it is surprising that after having heated the crank disk with a gasoline torch for over 12 hr. it could not be made hot enough to complete the job by the method originally intended. The accompanying engraving gives an idea of how the crank disks of large engines are heated rapidly with very simple apparatus.

Large C-clamps, Fig. 1, screwed on each side of the crank, as shown in Fig. 2, serve as supports for iron plates, which form a box-like enclosure around the pin bore in the crank. Sheet asbestos is then put around the plates to retain the heat when heating the crank.

Underneath the crank, a piece of $\frac{1}{16}$-in. sheet iron A, bent like a large pan, having holes punched in the bottom for draft, is attached to the shaft and to the C-clamps with wire, keeping the pan suspended close to the crank. A charcoal fire is kept going in this pan while the crank is being heated with the burner B. The charcoal fire retards the escape of the heat furnished by the burner.

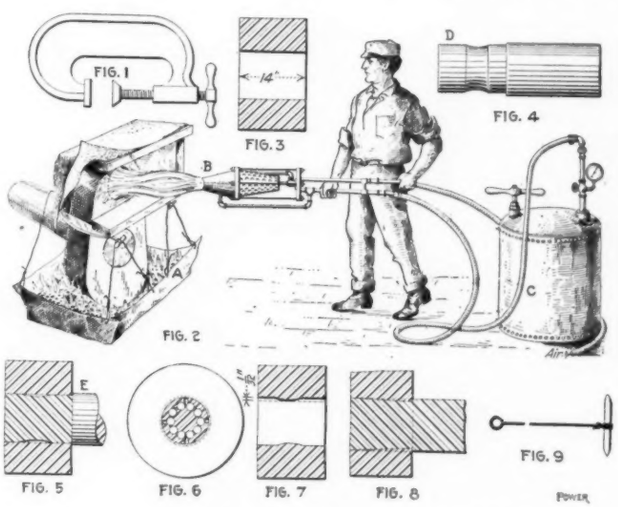
A kerosene tank C (usually of 30 gal. capacity) is used; the pressure carried is 25 lb. and is maintained by a hand pump. When the flame is made to play directly in the pin bore it will not take more than from four to five hours to bring a very large crank to a dark-red color corresponding to a temperature of about 800 deg. C.

The job of putting in a crankpin confronted the writer while he was in one of the French navy yards. The following plan was thought of, but it was desired to first ascertain that it would prove satisfactory. A disk of forged steel with an outside diameter of 37 in., a hole having a diameter of 15 in. and a depth of 14 in. (Fig. 3) was heated and the expansion, at a temperature of about 800 deg. C., found to be $\frac{1}{16}$ in. A pin, Fig. 4, was turned to $15\frac{1}{16}$ in. diameter with a groove D $\frac{1}{32}$ in. deep in a length of 6 in.

When the disk was of the right temperature the pin was forced into it. Naturally while the disk was hot, there was a space at E, Fig. 5, between it and the groove in the pin. When the piece became cold, holes were bored in the pin, Fig. 6, and four cuts chiseled quarterly so the pin could be extracted without injuring the surface of the bore. The inside of the hole was examined and measured and it was found that the metal had contracted to fit the shape of the pin, Fig. 7, which was the result desired.

Now being positive that this method was satisfactory it was decided to use a similar one in putting the crankpin in the engine awaiting repair.

The hole in the crank disk was 382 mm. (15.039 in.) in diameter, with a depth of 405 mm. (15.944 in.). The disk 306 mm. (12.047 in.) across. The expansion, at about 800 deg. C. figured to 2 mm. (0.078 in.). The new crankpin was turned 2 mm. (0.078 in.) larger than



How Crank Disk Was Heated and Crankpin Fitted to Disk

the hole at its extreme end, with a taper of ¾ mm. (0.029 in.) in the full length, as shown in Fig. 8.

While the heating operation was going on a pin-bore gage, Fig. 9, was made of ½-in. steel having a length, from point to point, equal to the large diameter of the pin. After heating about 4½ hr., the hole had expanded enough to admit the gage, consequently the crankpin was forced in with ease and left to cool. What happened is shown by the dotted lines in Fig. 8. The disk, after cooling, contracted, closing tightly around the tapered pin.

This method of putting in crankpins was adopted in the shops of that navy yard.

Testing Oils for Sulphur

By William Pattern

It is often advantageous for an engineer, using fuel oil or crude oil as fuel for his boilers, to know the amount of sulphur the oil contains. This can easily be done by the engineer, with a few simple chemicals and pieces of chemical apparatus.

Outfit

The following is a list of apparatus required for making a qualitative and quantitative test, the only expensive item being the analytical balance, which would cost from $12 to $40; ¼-in. glass tubing medium heavy, two 500-c.c. beakers, 1 oz. metallic sodium, 1 qt. saturated bromine water, one 4-in. sand bath (iron saucer-like dish), one bunsen burner with rubber tubing, one package of spun glass (wool), bunsen-burner tripod stand, one piece of wire-gauze netting, one mortar and pestle, one 1-lb. bottle of hydrochloric acid c.p., 1 oz. of barium chloride crystals c.p. This outfit may be bought at any chemical-supply house at a cost of about $3.

Should it be desired to determine the actual percentage of sulphur by weight, in the oil, it will be necessary to purchase the following additional laboratory equipment: one analytical balance, one set of weights (50 gm. to 1 mgm., and one 10-mgm. rider), six 1¼-in. procelain crucibles, one 2½-in. glass filter funnel, one package of first-quality filter paper, 1 oz. sulphuric acid, c.p., one filter stand, one wash bottle (can be bought all ready fitted up for use), one box of blue litmus paper (in books), one pair of bent iron tongs. This outfit will cost exclusive of the scales about $10.

Making Test Tube

Cut off piece of ¼-in. glass tubing 6 in. long and, holding an end in each hand with the center in the flame of a bunsen burner, rotate the tube constantly; when the glass becomes soft, steadily pull apart. Now hold the thin thread-like end of the tube in the flame of the burner with a constant rotating motion, until it melts and the result is a small closed tube 3 in. long. Rotating the tube as before, place the closed end in the flame and heat to redness, remove from the flame quickly and blow rather strongly in the open end until a bulb about twice the diameter of the tube is formed. Cut off the tube with a file, making it 2 in. in length.

Testing for Sulphur

The bulb is now half filled with the oil to be tested and three or four $\frac{1}{16}$-in. square pieces of metallic sodium put in the oil. Next push down in the tube a small wad of glass wool to within a short distance of the bulb, put three or four small pieces of metallic sodium on top of the glass wool and fill the tube to the top with more glass wool. Fill the sand bath with clean sand, bury the bulb of the tube containing the oil in the sand and place the lighted bunsen burner under the sand bath. Heat gradually for about 30 min. and then increase the heat until smoke issues from the mouth of the tube, when a light should be applied to the mouth of the tube and the vapor allowed to burn.

When the flame at the mouth of the tube goes out, remove the tube with the tongs from the sand bath, and pass it back and forth through the naked flame of the bunsen burner until all the oil is consumed. Put the tube in the mortar which has already been supplied with a small quantity of distilled water to which a few drops of saturated bromine water has been added. Cover the mortar quickly with a watch glass, as any free sodium which may be uncombined will burn and spatter.

Pound up the tube thoroughly with the pestle. Fold a filter paper and fit it in the glass funnel, wetting it with distilled water to make it stay. Place a beaker under the funnel and pour the contents of the mortar into the filter gradually, letting the liquid run down a rod placed against the lip of the mortar.

Wash out the mortar thoroughly with warm, distilled water, using the wash bottle, and run the contents through the filter. Wash the filter paper thoroughly with warm, distilled water from the wash bottle.

Place the beaker on the heating stand with a piece of fine wire gauze below. Add about 50 c.c. of saturated bromine water and boil the contents of the beaker until colorless to expell all bromine in the solution. Then add a few drops of chemically pure hydrochloric acid until the solution in the beaker turns blue litmus paper red, and boil again until colorless.

Wait until the boiling ceases and then add a few crystals of barium chloride on the tip of a small penknife blade. Boil again for 3 min. and if any sulphur be present a white precipitate of barium sulphate will be formed rapidly. A light precipitate indicates a small percentage of sulphur and *vice versa*.

Percentage of Sulphur

Should it be desired to weigh the barium sulphate to determine the percentage of sulphur by weight, proceed as follows:

Filter off the barium sulphate as in the previous operation to remove the glass. Filter very slowly and carefully, as barium sulphate is liable to work through the filter paper, and use only the first quality of filter paper. Wash the beaker thoroughly with hot water, using the wash bottle, and run the water through the filter. Wash the filter paper down three times with hot water from the wash bottle which can be placed on the wire gauze on the heating stand and heated with the bunsen flame. Let the filter drain and remove it carefully. Fold up the filter paper and place it in a porcelain crucible of known weight. Heat the crucible on a clay triangle over the naked flame of the bunsen burner until the filter paper is reduced to white ash. Let the crucible cool for 3 min., add three or four drops of diluted (1 to 4) sulphuric acid and warm very carefully until the acid ceases to give off white fumes. Then heat with the full force of the burner for 2 min. After cooling, weigh the contents. The increase in weight of the crucible will be the weight of the barium sulphate. This weight multiplied by the factor 0.137 will give the weight of the sulphur. All weights should be within ½ mgm.

When weighing the sample of oil, put the bulb in a cup and weigh, then put the oil in the tube and weigh the tube, cup and oil. The difference in weight equals the weight of oil.

The following will serve as an illustration of the weighing and calculations involved:

7.1850 gm., weight of cup, tube and oil

6.5740 gm., weight of cup and tube
0.6110 gm., weight of oil
5.4397 gm., weight of crucible and precipitate
5.4184 gm., weight of crucible
0.0213 gm., weight of barium sulphate

The weight of the sulphur would then be

$$0.0213 \times 0.137 = 0.0029181 \text{ gm.}$$

and the percentage of sulphur in the oil.

$$\frac{0.0029181}{0.6110} = 0.00477 = 0.477 \text{ per cent.}$$

The amount of sulphur in coal can also be determined by this method.

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Operating the Plant under Difficulties

SYNOPSIS—Difficulties met in the installation of an isolated plant, and incidentally a considerable reduction in the cost of power over purchased current.

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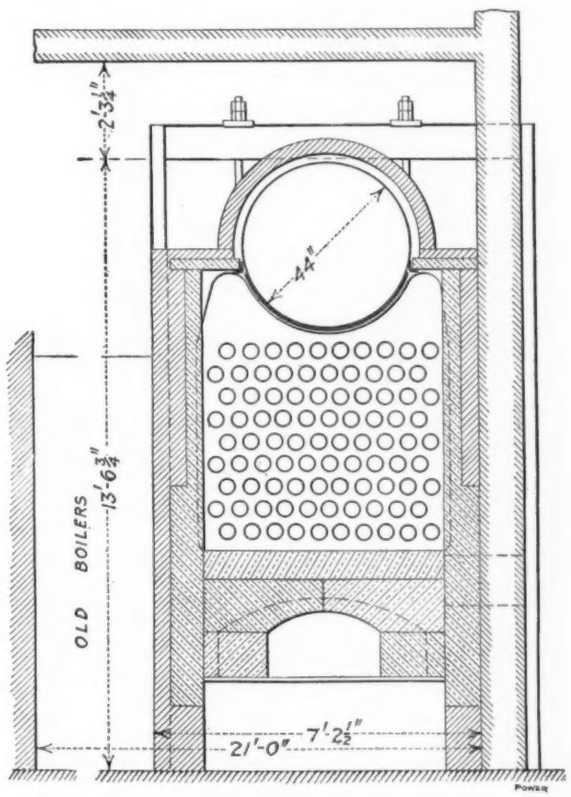
For three years the Mason-Seaman Transportation Co., of New York City, has been buying electric current for lighting and power for one of its buildings, a four-story brick structure Two horizontal tubular boilers have been operated to supply steam for heating and for a Westinghouse two-stage air compressor. The company operates the largest taxicab business in the city, and in the building just referred to houses about 600 machines. Due to the open driveways into the building, and the open windows to allow the exhaust gases from the machines to escape, 22,000 sq.ft. of coil surface is required to heat the building. Steam is also required for vulcanizing the tires, and on the top floor there is a good-sized machine shop for repairing and assembling new cars which are purchased in the rough by the company. The power load was, therefore, considerable, and at 5c. per kw.-hr. paid to the Edison Co., it amounted to a sum worth considering in the course of a year.

C. J. Rankin, chief engineer of the plant, decided that as long as boilers had to be operated for heating, a large saving could be effected by generating their own current for lighting and power. After using steam in an engine about 85 per cent. of the heat can be used to advantage in a heating system, so that in the present case the current for lighting and power should cost but very little more than the interest and depreciation on the investment for the generating equipment.

During the summer a 50-kw. C. & C. three-wire generator direct connected to an 11x12-in. Ames simple engine, was installed. It was put in operation on Aug. 22, and up to Feb. 15 was run 23½ hr. per day with such satisfactory results that it was decided to enlarge the plant, this being necessary as the company is erecting a new building beside the one it now occupies. On Feb. 15 a 100-kw. unit was put in operation and a 75-kw. unit is now being installed. These are of the same type as the 50-kw. machine, and the engines are 14x14 in. and 13x12 in., respectively. Since installing the 100-kw. machine it has been run daytimes under 80 per cent. load, and the small machine has been run nights under 95 per cent. load. When the new building is completed the generating equipment will be taxed to the limit.

Up to the time the large unit had been put in operation, Edison breakdown current had been maintained in the plant, but it has now been eliminated altogether. As shown by the records of the plant, the cost of operation has been less than 2c. per kw.-hr., as compared to 5c. formerly paid.

It was an easy matter to install the generating equipment, but the real difficulty came in equipping the boiler room with sufficient additional boiler capacity to handle the engine load. The boiler room was only 21 ft. wide by 37 ft. long, with head room of 15 ft. 10 in. It was impossible to install enough fire-tube boilers in this space to handle the load, and it was necessary to replace the two already installed with water-tube boilers of sufficient capacity. During the change, however, the plant had to be kept in operation, and one water-tube boiler had to be



SECTION THROUGH SINGLE-DRUM BOILER AND SETTING AS IT WILL APPEAR

installed, which would temporarily carry the load while the old return-tubular boilers were being removed and a second water-tube boiler was being put in place. The space between the setting of the return-tubular boilers and the wall opposite was only 7 ft. 2½ in., and as previously stated the head room was 15 ft. 10 in. A boiler which would carry the load and fit this space was hard to find, but finally the McNaull Boiler Manufacturing Co., of Toledo, Ohio, agreed to install one of its single-drum water-tube boilers, specially designed for the purpose. The boiler contains ninety 4-in. tubes 16 ft. long, with 1640 sq.ft. of heating surface. The drum is 44 in. in

diameter by 18 ft. long, and the grate 5 ft. 4 in. by 6 ft. 9 in. A McClave-Brooks grate was used and an Argand blower was installed to force the boiler considerably beyond its rated capacity of 160 hp.

To make matters worse, the draft was not good, as the stack was only 24 in. square and 91 ft. high. Due to the limited space, no provision could be made for cleaning the boiler, and on Mar. 7, after it had been in operation for two months, the flue ashes were over the bottom tubes at the rear of the setting and at the bridge-wall near the sides of the setting. The space at the center had, of course, been kept clear by the force of the draft from the Argand blower. Besides there were chinks in the setting, and the top of the boiler was not covered, so that there was ample opportunity for air leakage into the combustion chamber.

Since Jan. 14, the boiler has been supplying the entire demand of the plant, and this from Jan. 14 to Feb. 15 consisted of the 50-kw. generating unit, the two-stage Westinghouse air compressor rated at 40 hp. and running 75 per cent. of the time, live steam as well as exhaust from the engine for the heating, and also steam for the following pumps: one 2¾ and 4¾ by 4-in. house pump running 75 per cent. of the time; one 4¾ and 5 by 5-in. sump-well pump running 30 per cent. of the time, and one 6 and 4 by 6-in. boiler-feed pump running intermittently to supply the feed water. Since Feb. 15, 80 kw. has been generated for light and power, instead of 50, thus putting additional load on the boiler. About eight tons of No. 2 buckwheat coal was burned per day of 24 hr.

Considering the adverse conditions, the results are remarkable. That the boiler was able to carry the overload is worthy of comment, and the cost of current for a plant of the size and the conditions under which it was operated is low.

On Mar. 7 the installation of the second water-tube boiler had been nearly completed. This is a two-drum boiler rated at 249 hp. It is of the same length as the other, has 135 four-inch tubes and it is equipped with the same type of grate and blower. When this boiler is ready to supply steam, and the first boiler has been provided with a proper setting, better results are expected. The engineer hopes to produce current for light and power at an operating cost approaching 1c. per kw.-hr., and when the heating system is in full blast he can probably do it without any difficulty. Further results from this plant will be watched with interest.

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Power Transmitting Capacities of Pulleys

By John S. Leese

SYNOPSIS—A number of tests showed the maximum transmitting capacity of paper pulleys to be 29.8 per cent. better than cast-iron and 107.7 per cent. better than wood pulleys.

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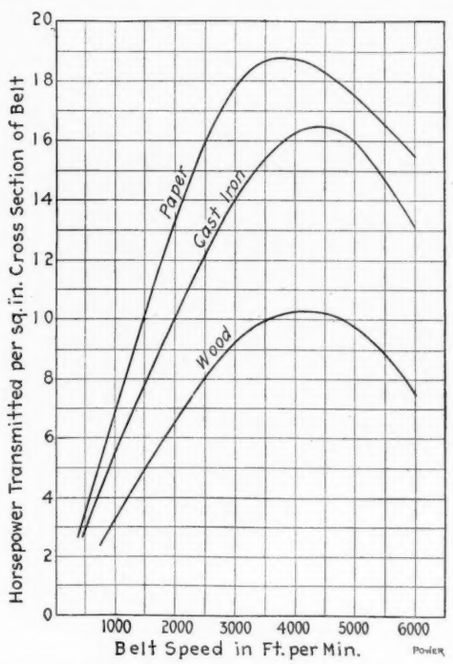
The writer recently came across the accompanying data which are the results of tests carried out less than two years ago but which he was then unauthorized to publish. The object of these tests was to determine the relative transmitting powers of wood, paper and cast-iron pulleys with leather belts, and the accompanying results, the average of twenty independent readings at each speed, came rather as a surprise to the interested parties.

Belt slip and tension were calculated at the same values for each pulley so that a working basis fair to all the pulleys was obtained. The belt tension (the tension in the driving side plus half the tension in the slack side) was constant at all speeds. The results show the maximum transmitting capacity of paper pulleys to be 29.8 per cent. better than cast-iron and 107.7 per cent. better than wood pulleys, the maximum figures for each pulley occurring at different speeds.

It may be noticed that in each case the capacity falls off more rapidly after passing the maximum than it increases before reaching this value. This tendency is more marked in the cast-iron pulley. The wood pulley "hangs on" around its maximum over a greater range of belt speeds than either of the others.

During these tests measurements were made to compare the temperatures of the surfaces of each pulley, first with constant horsepower (8 hp. per sq.in. cross-section of the belt) and second with constant belt speed (3500 ft. per min.). The results obtained showed that with constant power, wood pulleys were the hottest, paper next, and cast iron coolest. With constant speed the paper was the hottest and the wood a very close second.

At the completion of the experiments the belt speed was increased with the object of determining the speed



Belt Speed-Horsepower Curves for Different Pulleys

at which the wood pulley would begin to char. This was found to occur at approximately 7200 ft. per min. The paper pulley was next tried for charring, but no trouble ensued up to about 7900 ft. per min. It was im-

possible to go above this speed as the belt flew off the pulleys repeatedly when it was attained. After several attempts to go higher, one of the experimenters had a narrow escape from the flying belt as it came off the pulleys, and further trials were abandoned.

New American-Ball Paper-Mill Engine

The fundamental requirements of a variable-speed paper-mill engine are a speed range equivalent to the desired speed range of the rolls, and, as near as possible, perfect regulation at all speeds. To meet these requirements the American-Ball four-cylinder paper-mill engine, illustrated herewith, has been designed.

The four cylinders are arranged in pairs at right angles, making an engine of two units, each of which has a vertical and horizontal cylinder, Fig. 1. One vertical and one horizontal piston drive one crankpin, and the other vertical and horizontal pistons a second crankpin 45 deg. from the first, so that there are eight power strokes per revolution, evenly distributed. A counterweight on each crank transfers the horizontal reciprocating forces from a horizontal to a vertical plane, in which they meet equal and opposite reciprocating forces from the vertical reciprocating masses, which, therefore, neutralize unbalancing and permit operation at from 400 to 500 r.p.m. The engine may be operated at as low a speed as 50 r.p.m. with good regulation, so that a total speed range of 8 to 1 and even 10 to 1 may be obtained. The engine may be coupled directly to the line shafting.

In Figs. 2 and 3 are shown the speed-changing and governing mechanisms. Two governors are used, each of standard type, specially improved and adapted to this particular service. The first governor is used as an automatic safety stop and is placed nearer the steam-supply pipe, at the right of Fig. 2. It is belt driven from the engine shaft and has an automatic tripping mechanism. The steam valve remains wide open throughout the normal range of speeds for which the engine is designed, but if the speed exceeds the predetermined limit the mechanism is tripped and the weighted lever closes the steam valve. At all normal speeds this governor valve has no throttling effect.

The second governor, at the left in Fig. 2, controls the engine speed and is driven through the variable-speed friction device also shown.

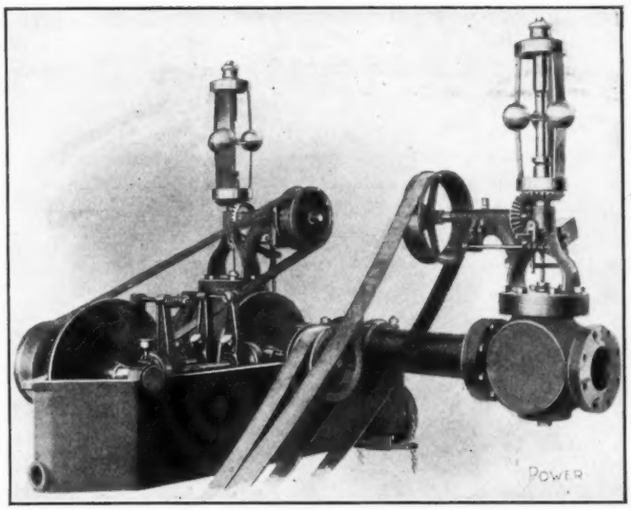


FIG. 2. VIEW OF THE BALL GOVERNOR

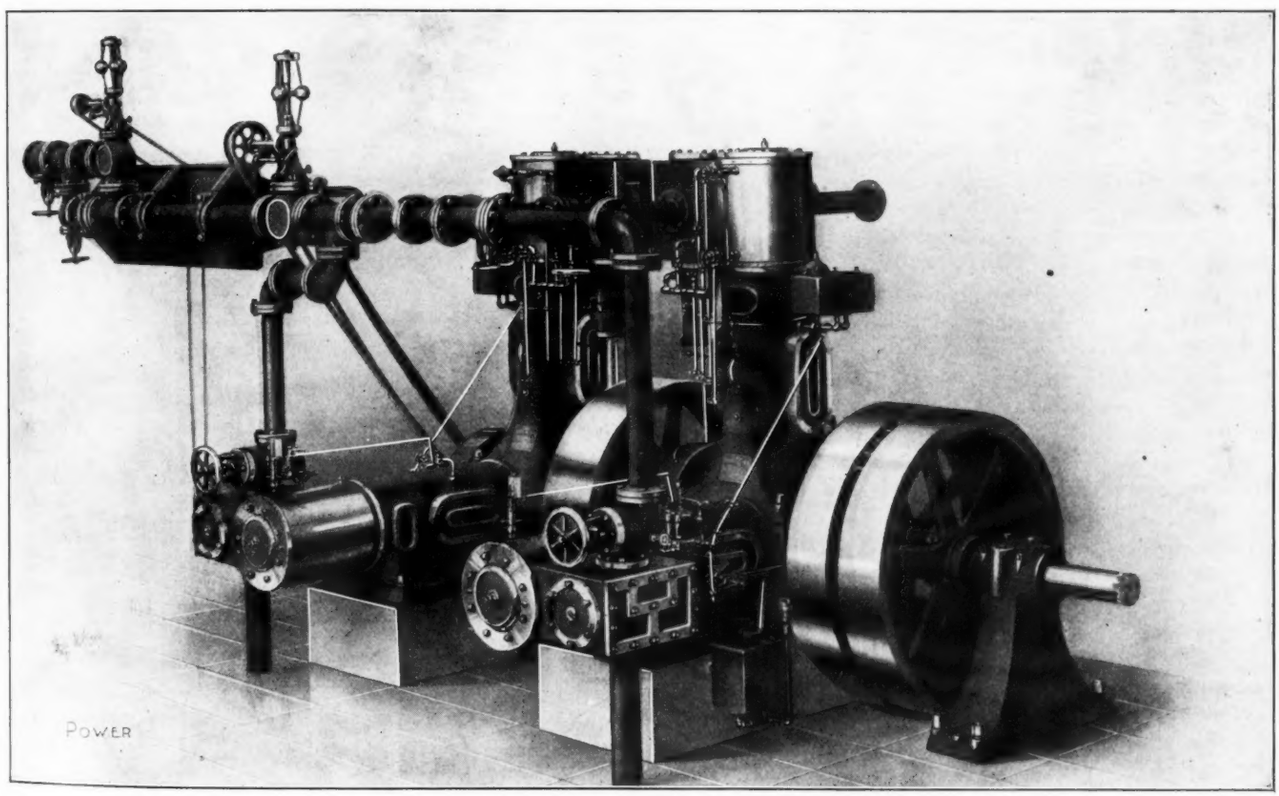


FIG. 1. AMERICAN-BALL FOUR-CYLINDER, VARIABLE-SPEED, PAPER-MILL ENGINE

To prevent speed surges, a standard governor has been equipped with a mechanism comprising stabilizing springs and an oil pot. The piston of the oil pot receives motion from the governor stem, through the spring stabilizing device, which absorbs shocks induced by sudden changes in the speed of the governor balls. This stablized

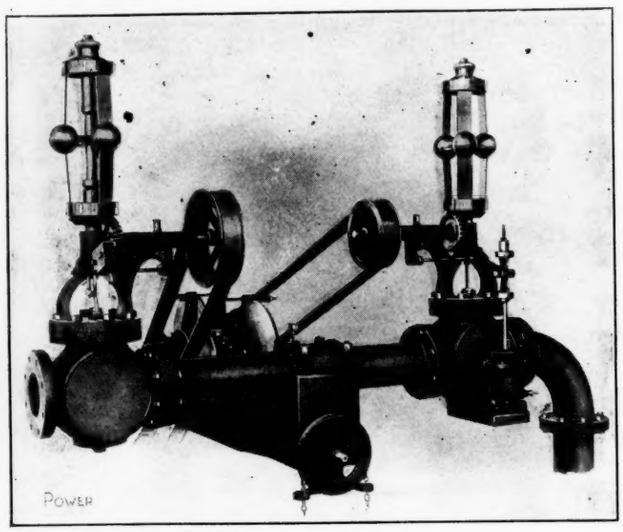


FIG. 3. BALL GOVERNOR AND SPEED-CHANGING MECHANISM

governor is driven from the engine through a variable-speed friction device. A belt from a pulley on the engine shaft drives a pulley on the friction device, which drives a second pulley through two disks and two pairs of friction wheels. Any speed from minimum to maximum may be imparted to the second pulley, which, in turn, drives the governor.

The two large iron disks are each keyed to a pulley shaft. Bearing on the surface of these disks are four small friction wheels, one on each side of each disk. The driving disk, keyed to the shaft of the driving pulley, rotates the two friction wheels, held against it by springs, and the second pair of friction wheels drives the second disk and the pulley keyed to its shaft.

The speed is changed by shifting the position of the friction wheels, which are carried by four rockers located in pairs; each pair is held to a shaft which passes through guides and may be shifted as desired by a chain wheel and lead screw cut at one end. Each pair of rockers is held together by springs, thus keeping the friction wheels firmly against the disks. All bearings are of the ball-bearing type.

This engine is built by the American Engine Co., Bound Brook, N. J.

Flexible Metallic Combination Hose

A new coupling, known as the J-M flexible metallic combination hose, consists of a durable rubber hose, protected against outward injury by a stout metal armor. The armor is made in the form of a ribbon, with crimped edges, forming, when wound, a continuous interlocking flexible spiral, which is designed to be practically pressure-tight in itself, without the inner tube.

As the interlocking construction of the spiral restricts the curvature of the hose, sharp bends are impossible. Consequently, the inner tube cannot kink or flatten, and is always open to its full diameter, permitting an unrestricted flow of steam, gas or fluid.

Owing to its strength, the armor is practically proof against damage from the outside. Service tests show that it will resist a crushing strain of 300 to 800 lb. to each four turns of the spiral, depending on the size of the hose, while it is capable of withstanding high internal-working pressures.

The inner tube is never subject to any pulling strain, as the armor is stretched to its maximum length before the former is inserted. All the working strain comes on the armor, which is tested to resist an end pull or thrust of 1000 to 2000 lb. The exterior surface does not become excessively hot when used for steam service, and can be conveniently handled.

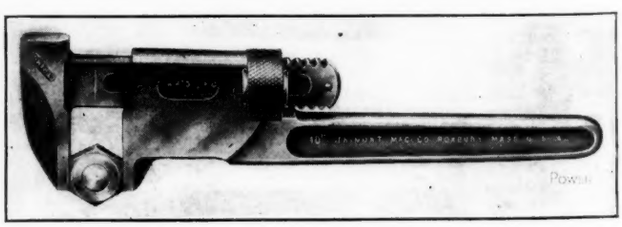
Specially designed couplings of malleable iron or brass are furnished with each length of hose. Each coupling consists of an outer sleeve, into which the metal armor is threaded and riveted, an internal nipple, tapered on one end to fit tightly inside the inner tube, and the lock or binding nut which serves to wedge the internal nipple into the inner tube and hold it tightly against the inner walls of the outside sleeve. The outer end of the internal nipple is furnished in male or female type, threaded to meet any standard requirement.

This hose can be furnished in any length, in any inside diameter up to 12 in., of any metal, and for all working pressures. It is also made with an inside pressure-tight metallic lining as well as outside metal armor, for suction service, oils, etc. For washing out boilers, for roundhouse work, and for use in other places where steel would corrode, copper armor is used.

This hose is made by H. W. Johns-Manville Co., New York City.

Hammer-Head Monkey-Wrench

The hammer-head jaw of the wrench shown extends outward instead of opening toward the handle to gain a longer leverage in proportion to the size of the nut. The handle contains a housing through which the jaw slides,



NEW MONKEY-WRENCH

and a nut guard protects the adjustment of the wrench. This guard keeps the adjustment from shifting through jar or vibration.

The wrench is made of drop-forged steel, in a variety of sizes, by the Trimont Manufacturing Co., Roxbury, Mass.

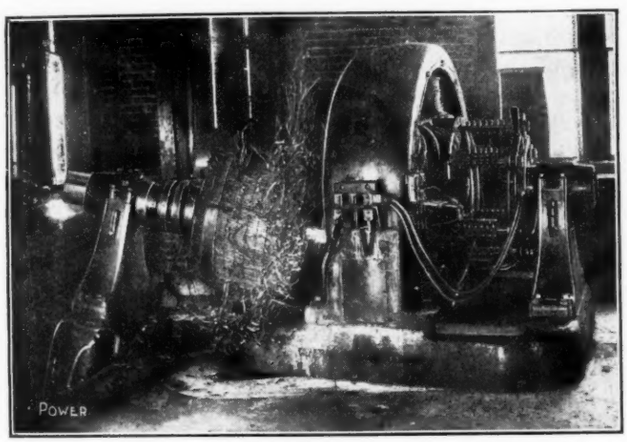
The custom of whitewashing the surface of loaded coal wagons has been inaugurated in Germany as a security against coal pilfering during transportation. Where the experiment has been tried it is said to have been successful.

ELECTRICAL DEPARTMENT

Racing of Rotary Converter

The accompanying photograph shows the result of the racing of a 300-kw. rotary converter, which occurred on Apr. 5 at one of the substations of the Springfield, Troy & Piqua Ry. Co., Springfield, Ohio.

When a series-wound rotary converter is running in parallel with other machines supplying a direct-current system, and its alternating-current supply is interrupted without the circuit-breaker on the direct-current side being opened, the current from the other machines will feed



SHOWING EFFECTS OF RACING

back, running it as a series motor. Under these conditions there will be no load on the converter and it will immediately run away, unless some protective device opens the direct-current circuit. This is what happened in the present case.

The converter was protected by a low-voltage release, also a speed-limit device on the end of the armature shaft. This consists of a revolving contact piece, which under the action of centrifugal force, when above a certain rotative speed, makes contact with a short-circuiting ring, thus demagnetizing a solenoid on the circuit-breaker, dropping the plunger and opening the circuit.

For some unknown reason this device failed to operate, although it had been inspected recently and found in working order. Besides wrecking the machine, as shown, the building was damaged to some extent.

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Decreasing Frequency of Transformers*

BY F. A. ANNETT

The losses in a transformer are divided into two parts, namely: Iron losses and copper losses. The iron losses are due to hysteresis caused by the molecular friction of the iron and to eddy-current losses caused by the varying magnetic flux inducing electromotive forces in the core. The iron losses are independent of the load, for they are dependent on the magnetic density in the core, which is about the same at no load as at full load and go on while the transformer is connected to the line.

The copper, or I^2R, losses increase with the load. The combined effect of the iron and copper losses is to heat up the coils and core so that the amount of power a transformer is capable of delivering is limited by the heating effect. The watts expended in heating the transformer is the difference between the watts input at the primary and the watts output at the secondary.

The hysteresis losses vary as the 1.6 power of the magnetic density and directly as the frequency. The eddy-current losses vary as the square of the frequency and magnetic density.

Considering the e.m.f. induced in the primary equal and opposite to the impressed e.m.f., a condition approached in a well designed transformer under no load.

Let

E_p = Impressed primary voltage;
ϕ = Total flux through the core;
T_p = Number of turns in series on the primary coil;
f = Frequency in cycles per second.

$$\text{Then } E_p = \frac{4.44\,\phi\,T_p f}{10^8} \qquad (1)$$

From the formula (1) it is evident that if E_p and T_p are constant, and the frequency (f) is changed, the flux (ϕ) must change in inverse proportion; that is, if the frequency is decreased the flux must increase in the same proportion. Let

V = Volume of iron in cubic inches in the core of a given transformer;
B = Magnetic density in lines of force per square inch;
w = Watts loss per cubic inch per cycle for a density B;
f = Frequency in cycles per second;
W_h = Total watts loss due to hysteresis = Vwf.

If the frequency f is changed to the frequency f' the magnetic density will change from B to $B' = \frac{Bf}{f'}$. Let

w' = Watts loss per cubic inch per cycle for a density B';
$W'h$ = Total watts loss due to hysteresis for a frequency f'.

$$\text{Then } w' = \frac{w\,B'^{1.6}}{B^{1.6}} = \frac{w\left(\frac{Bf}{f'}\right)^{1.6}}{B^{1.6}} = \frac{w\,B^{1.6}f^{1.6}}{B^{1.6}f'^{1.6}} = \frac{wf^{1.6}}{f'^{1.6}}$$

$$\text{And } W'h = Vw'f' = \frac{Vwf^{1.6}}{f'^{1.6}}f' = \frac{Vwf^{1.6}}{f'^{0.6}}$$

Since V = Constant; let

W = Watts loss per cycle for a frequency f = Vw.

$$\text{Then } W'h = \frac{Wf^{1.6}}{f'^{0.6}} \qquad (2)$$

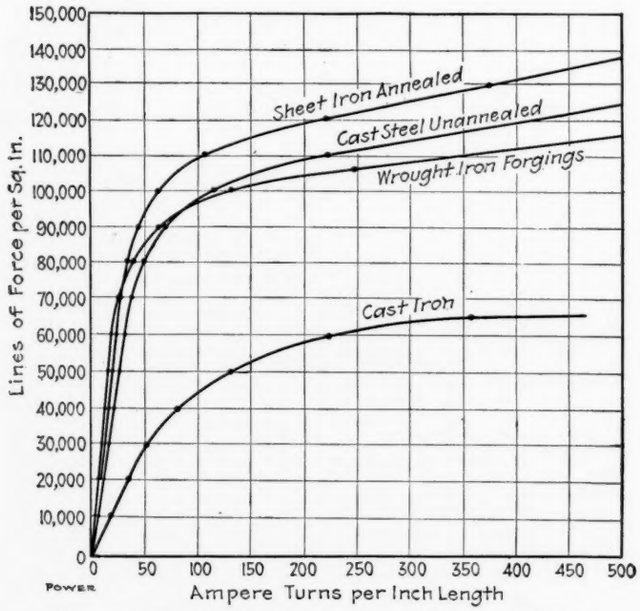
*This article was prepared in response to several inquiries from readers relative to the effect on the transformer losses, of changing from 60 to 50 cycles.

That is, the watts loss ($W'h$) due to hysteresis in a given transformer for any frequency is equal to the watts loss per cycle (W) times the 1.6 power of the frequency (f) for which the transformer is designed, divided by the 0.6 power of the frequency (f') that the transformer is working on.

Since the eddy-current losses vary as the square of the frequency and magnetic density they will remain about constant for any frequency in a given transformer, for the magnetic density varies inversely as the frequency.

It is evident from formula (2) that if the frequency is decreased the losses due to hysteresis will be increased and, as stated, the hysteresis and eddy-current losses should be kept as small as possible, for they are going on all the time as long as the transformer is connected to the line; also the magnetic density varies inversely as the frequency, requiring greater magnetizing current.

Up to a magnetic density of about 70,000 lines per square inch in a good quality of transformer iron (see the accompanying curves), the flux increases directly as the ampere turns per inch of length. At this density



AMPERE TURNS PLOTTED AGAINST LINES OF FORCE

about 25 ampere turns per inch length of core are required to set up the flux. At 100,000 lines per square inch it requires 65 ampere turns per inch length and at 140,000 lines per square inch (this is about the point of saturation) it requires about 600 ampere turns per inch length.

The magnetizing current may be expressed as

$$I_m = \frac{L\,(IT)}{T_p}$$

where

I_m = Total current required to set up the flux through the core;

(IT) = Ampere turns per inch length = average turns, T, in series per inch of length times I, the total current in the coil;

L = Mean length of transformer core;

T_p = Total number of turns in series on the primary coil.

Since the flux increases inversely as the frequency it is evident that if the frequency is greatly decreased the flux will become very high, and above 70,000 lines of force per square inch, the ampere turns (IT) per inch length increase very fast. If this element becomes very large (I_m) the total current required to set up the flux also becomes very large, although this current is 90 deg. behind the e.m.f. and is wattless. It is, nevertheless, loading up the line and alternator, and reducing the power factor of the whole system, thereby reducing the useful working capacity.

Since, the current required to supply the iron losses is in phase with the e.m.f. and the magnetizing current is 90 deg. behind the e.m.f., the no-load or exciting current will be the resultant of the magnetizing current proper and the current required to supply the core losses, and may be expressed by the formula:

$$I = \sqrt{\left(\frac{W_h + W_e}{E_p}\right)^2 + \left(\frac{L\,(IT)}{T_p}\right)^2}$$

W_e being the watts loss due to eddy currents, and the cosine of the angle of lag between this resultant and the e.m.f. will be the power factor of the transformer. Therefore, the greater the magnetizing current component, the lower the power factor of a given transformer at no load; this will cause a lower power factor at full load.

The increase in the magnetizing current is dependent upon the magnetic density per square inch for which the transformer is designed. Assume that the magnetic density is low, say, 30,000 lines per square inch. If the frequency is decreased by one-half, the magnetic flux will be doubled, and the exciting current will be approximately doubled, but if the transformer is designed to work at a magnetic density of 60,000 lines to the square inch, and if the frequency is decreased by one-half, the magnetic flux will be doubled as before, and the magnetizing current will be increased approximately eighteen times.

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Unequal Alternator Voltages

Referring to the inquiry by H. J. B. and the answer thereto, printed on page 506 of the Apr. 8 number of POWER, it may be of interest to point out that unequal voltages from alternators of the same size and type, running at equal speeds and with equal field excitations, could be due to eccentricity of the armature of one machine or to a slight difference in the air-gap lengths of the two. It is difficult to build two machines with air gaps of precisely the same effective lengths, and a small difference is noticeable in the generated voltage.

It is possible that in the case stated, one armature was not in the exact center of the circle formed by the pole faces. If this be true, the machine with the eccentrically mounted armature would generate a lower voltage than the one with a truly centered armature. The reason is that the shortened air gaps around one-half of the armature circumference cannot compensate fully for the lengthened ones around the other half, because the excessive magnetic flux across the short gaps will increase the flux density in the corresponding magnet cores and this will choke down the increase in flux below the point necessary to compensate for the weakened poles diametrically opposite.

CECIL P. POOLE.

Atlanta, Ga.

GAS POWER DEPARTMENT

Performance of Engine Operating on Coke-Oven Gas

The adaptability of the internal-combustion engine to the intermittent service required in many gas-pumping stations has led a number of illuminating-gas companies to install such engines in connection with rotary blowers or exhausters for handling large volumes of gas at low pressures. The low stand-by loss in conjunction with the high thermal efficiency of the gas engine results in a low cost for power, which is even more marked when some such fuel as coke-oven gas is available.

The People's Gas Light & Coke Co., of Chicago, has recently made an installation of this kind at its 110th St. pumping station. The equipment now consists of two 18x 24-in., tandem, double-acting, Buckeye gas engines, each driving a Piqua blower through a flexible coupling. A third unit of the same kind and size has been purchased and its installation is now under way.

The engines are of the standard Buckeye design, as illustrated in the Nov. 28, 1911, issue of POWER, except that the inlet valves are water cooled to assist in handling the high hydrogen gas which is obtained from a neighboring byproduct coke-oven plant of the Semet-Solvay Co.

A typical analysis of this gas after being purified is as follows: CO_2, 1.9; C_2H_4 and C_2H_6, 4; O, 1.6; H, 51.8; CH_4, 30.6; N, 5. The heat value ranges from 560 to 590 B.t.u. per cu.ft. This gas, after being properly

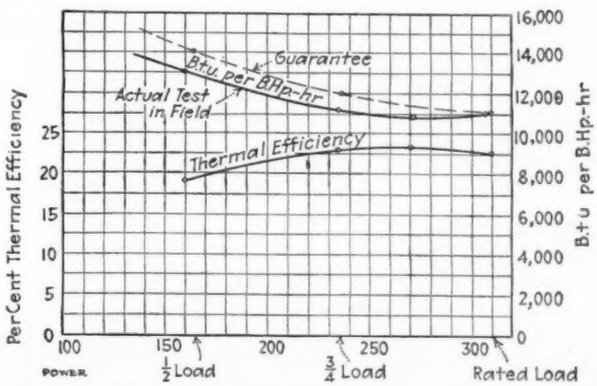

FIG. 2. RESULTS OF ECONOMY TEST

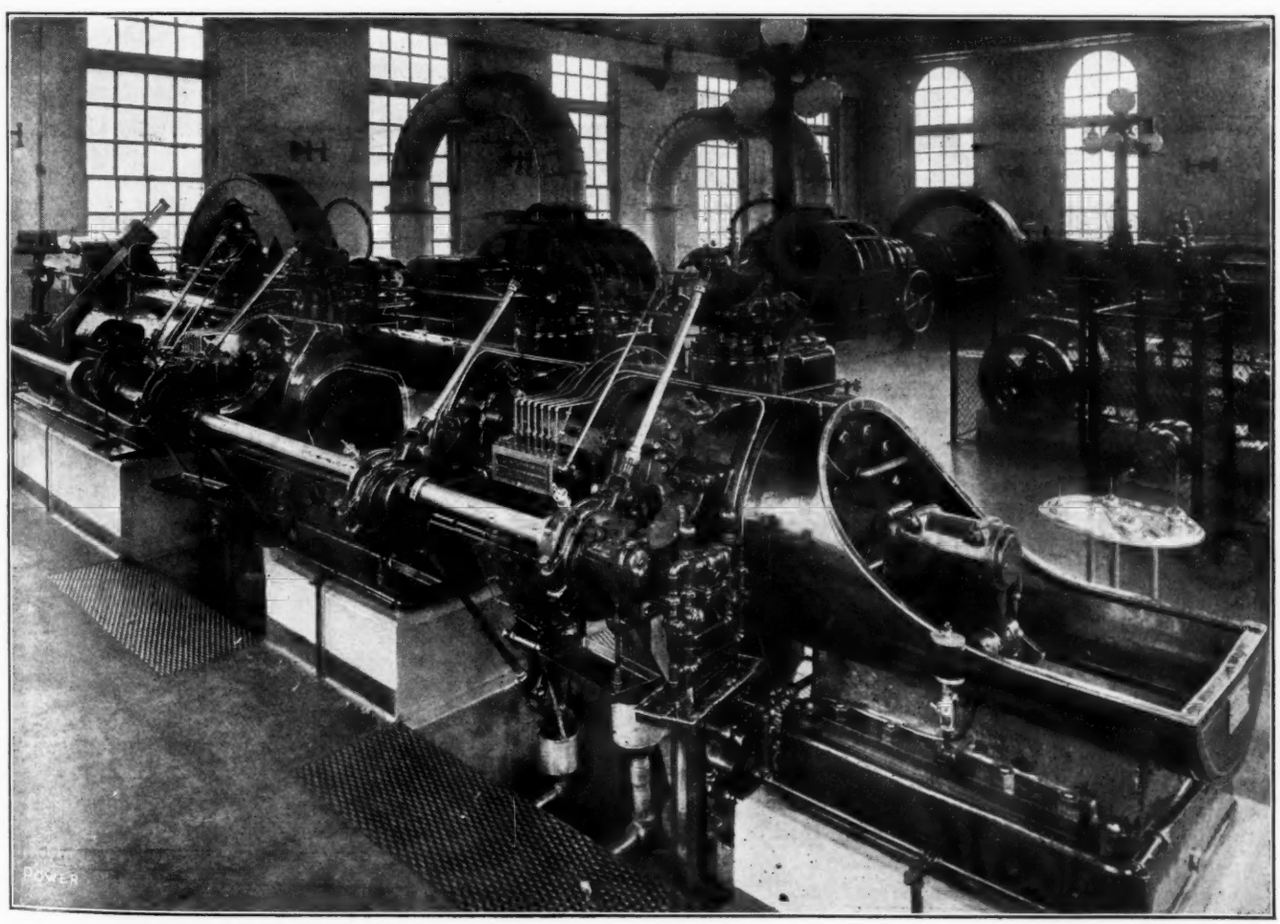

FIG. 1. ONE OF THE ENGINES AT THE PEOPLE'S GAS LIGHT & COKE CO.'S PLANT

enriched to meet the requirements of the Chicago ordinance as to candlepower and heat value, is pumped by the exhausters to the lighting mains.

Inasmuch as the quantity of gas pumped is variable, the engines are arranged to operate at any speed between 75 and 190 r.p.m. This is accomplished by a shifting weight in connection with the regular engine governor. Once set for the desired revolutions per minute this device holds the engine speed constant regardless of changes in the load caused by variations in the pressure against which the exhausters deliver the gas.

An economy and capacity test of these engines was made by the gas company's engineers on June 26 to 28, 1912. Results of the economy test are shown in Fig. 2. From this it will be noted that the highest thermal efficiency, 23.4 per cent., was attained at about seven-eighths load, although the curve is very flat from three-fourths to full load. The guaranteed heat consumption per brake horsepower-hour at various loads was as follows:

Load	Brake Horsepower	B.t.u. per Brake Horsepower-Hour
½	165	14,000
¾	236.5	12,000
Full	310	11,000

Reference to the curves will show that the actual performance was well within these figures.

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Quality and Uniformity of Producer Gas

By Reginald Trautschold

The percentage of hydrogen in producer gas determines its richness, and upon the uniform quality of the gas depends largely the performance of the engine.

An insufficient supply of water vapor or steam will not only fail to furnish the requisite proportion of hydrogen, but the temperature of the fuel bed will become too intense. Too much water vapor, on the other hand, reduces the temperature of the fuel bed to the extent that it is unable to break up the steam into its component parts, so that there is again a scarcity of hydrogen in the delivered gas. The supply of water vapor then must depend upon the intensity of the heat in the producer and it was on this point that so many of the first installations of gas producers, where steam was obtained from some independent source and could not be readily proportioned to meet the exact requirements of the producer, proved unsatisfactory.

The necessity for uniform richness of the gas is now well recognized and, although careful tests have failed to establish any exact rule for the amount of water vapor required per pound of fuel consumed, the most experienced manufacturers of gas producers state that from 0.6 to 1 lb. of steam is required per pound of fuel consumed. This is very satisfactorily taken care of in certain types by causing the producer itself automatically to regulate and supply the water vapor carried through the bed of incandescent fuel. This can be done quite accurately as the heat of the fire bed is directly proportional to the amount of air supplied, which, in turn, is dependent upon the suction created by the engine and is thus proportional to the engine requirements of fuel. The supply of water vapor must then also be proportional to the fuel requirements of the engine and this is accomplished in several ways.

In the Smith producer, the fact that air at any given temperature is capable of carrying only a certain amount of water vapor in suspension (point of saturation) is made use of for properly proportioning the mixture of air and water vapor supplied to the producer. This proportion of air and water vapor not only maintains a producer fire at a satisfactory temperature, but also supplies the necessary hydrogen for a uniform mixture. The hot jacket water from the engine is utilized; being brought to a still higher temperature by heat reclaimed from the engine exhaust. The hot water is then discharged into a "saturator" so constructed that the air supply passes up through a bed of coke over which the heated jacket water is sprayed. The air supply for the producer, its volume proportional to the engine requirements for fuel, is passed up through the mass of coke and absorbs water vapor up to the point of saturation at the temperature of the mixture leaving the saturator. A thermostat in the path of the saturated and heated air, just before it enters the producer, regulates the amount of heated water discharged over the coke bed and thus maintains constant the temperature of the air supply and the amount of water vapor it is capable of carrying. The air supply being proportional to the heat of the fuel bed, the water supply is also correctly proportioned.

The Akerlund bituminous producer of the down-draft type regulates the supply of water vapor in a somewhat different manner. A water tank or vaporizer is situated within the producer shell surrounding the top of the ash bed, adjacent to the live-fuel bed. This tank is supplied with preheated water from the water-cooled top of the producer, the temperature of the supply being practically constant for any normal condition of fire bed. The heat from the fire converts this preheated water into vapor at a rate directly proportional to the temperature; this vapor rises and mixes with the air supply, which is also heated by circulating within the producer shell, and the temperature of which is likewise proportional to that of the fire bed. The heated air carries a quantity of water vapor which varies directly with the intensity of the heat of the fire and thus, as the air supply is proportional to the rate of gas production, a constant percentage of hydrogen is maintained in the delivered producer gas.

The Akerlund anthracite producer of the up-draft type uses a slightly different arrangement for maintaining the correct amount of hydrogen in the gas. In this producer, the top is also water cooled, forming a vaporizing chamber, and the air supply, after being heated by passing between the shell lining and the firebrick lining, circulates in the vaporizing chamber. After absorbing water vapor to the point of saturation, the heated air is drawn down inside the lining, and is delivered under the fire bed; it then passes up through the bed of incandescent fuel. The supply of water vapor is thus automatically regulated by the temperature, which is similarly regulated by the demands for gas so that the resulting gas is uniform in quality.

The Otto suction-gas producer employs practically the same method of regulating the supply of water vapor as is used in the anthracite-coal type of Akerlund producer. In fact, every successful producer makes provisions for regulating the vapor to conform to the rate of gasification. The apparent simplicity of the suction-gas producer will doubtless cause incorrectly proportioned and poorly de-

signed producers to continue to appear on the market. Therefore, it is still imperative for the purchaser to pay particular attention to the provisions for supplying a gas of uniform richness. This is a matter of importance that cannot be decided from records of economic production of power as indicated by tests that may have been conducted under unusually favorable conditions.

The early difficulties with producers depending for their operation upon a water-vapor supply that did not vary with the heat intensity of the fire bed, led to other means for keeping the temperature from becoming excessive and for supplying the elements necessary for the reduction of carbon dioxide to carbon monoxide. The most successful substitute was the exhaust gases from the engine. This is the method employed by the Tait producer and has given excellent results. The principle component of the exhaust gases from the engine, other than nitrogen, being carbon dioxide, the reduction taking place in the producer is very similar to that occurring when water vapor is used, the carbon dioxide combining with the incandescent carbon to form carbon monoxide, the inert nitrogen and the heat absorbed in reducing the carbon dioxide serving to keep down the temperature of the fire bed. The gas delivered is very uniform in quality and differs from that generated in a producer utilizing water vapor, by containing a somewhat smaller percentage of all the component gases other than marsh gas, of which there is a slight increase, and an increase in the percentage of nitrogen in the gas delivered from the producer.

High-Tension Ignition with Batteries

By A. L. Brennan, Jr.

The chief difference between high- and low-tension ignition is that the former system requires a secondary current in order that the resistance offered by the gap between the points of the spark plugs may be overcome. A high-tension system is more likely to short-circuit than low-tension and, therefore, it is important that well insulated wiring be used and that care be exercised to see that the insulation is not broken down by being repeatedly subjected to the elements, or to excessive chafing or vibration. The coils and batteries should be kept in a dry, clean place and if possible the wiring and spark plugs should also be protected.

Some troubles which point to faulty ignition, may be due to other causes. For instance, misfiring is often due to some derangement of the ignition system, but it may also be due to faulty carburetion or other causes.

As previously stated high-tension ignition may be divided into two parts: the primary and the secondary circuits. Therefore, if one will first become familiar with these parts and their corresponding relation, he will be able to distinguish and locate a trouble at once.

Consider a multi-cylinder engine that refuses to start, due to some fault of the ignition. First locate the seat of the trouble by turning the engine over to the several firing points with the switch in position (battery). If the motor is fitted with single-coil units each of which has a vibrator—it should be observed if each of these buzz; if so, the trouble is not in the primary circuit, comprising the batteries, contact points of vibrator, timer and battery connections or other primary wiring. From this the trouble is immediately traced to the secondary of the coil, high-tension wiring or spark plugs.

In order to see if a high-tension current is reaching the spark plugs, the motor should first be turned over to the firing point of No. 1 cylinder. Then throw out the switch and disconnect the secondary wire from the spark plug; again throw in the switch and, with the coil vibrating, hold the secondary wire terminal about 1/8 in. from the top of the plug. Observe if a good spark appears between the terminal and the plug. If one appears the trouble is in the plug, but if no spark appears the trouble is in the secondary windings of the coil, loose connection of the high-tension wires or the wrong unit is in circuit, that is, the motor may be on the firing point of another cylinder.

As to the spark gap mentioned, this may seem large, but it should be remembered that a spark which is efficient under the high pressures of the combustion chamber should easily jump a wider gap under atmospheric pressure. The spark-plug points should be clean and be set about the thickness of a dime apart.

Going back a step, suppose that when the engine is turned over, the vibrator fails to buzz. This would indicate trouble in the primary circuit, which might be due to weak or depleted batteries, timer points stuck, disconnected or broken wires, broken connections inside the coil, or to the vibrator contact points being stuck. On the other hand, if some, but not all, of the cylinders operate, it would indicate that the trouble was in the controlling features of the high-tension circuit. One or more of the following may be at fault: Tremblers on the coil stuck or out of adjustment; timer points not closing that circuit, or internal defects in the coil.

When adjusting coils always exert the least tension possible on the vibrators that is consistent with good results. Severe vibrator adjustments do not increase the efficiency of the motor but, on the other hand, cause additional demands upon the battery.

CORRESPONDENCE

Removing Piston Rings

In the Apr. 8 issue, A. L. Brennan, Jr., says, "It is advisable to remove the lowest ring first, for, otherwise, difficulty may be experienced while removing these rings last, as they would have a tendency to drop into the grooves of the other rings should the guide strips slip."

While this may be true with rings that are very limber, yet when the rings are stiff enough to offer much resistance to being pressed down in the groove, it is easier to take a ring over the empty grooves than over the other rings. When there are no strips of metal handy, a ring can be taken over grooves by keeping one side ahead of the other so the ring and groove are not parallel.

As to using emery cloth to remove carbon from rings and grooves; why is not a scraper to be preferred? A scraper can be made in a few minutes from an old file which will remove the carbon faster and as clean as anything.

Hawley L. Scott.

Bangs, Ohio.

REFRIGERATION DEPARTMENT

Running a Refrigerating Plant

By William L. Keil

If the refrigerating plant has been shut down for the winter months and is to be started up, quite some attention must be given to the various machinery and apparatus before a wheel is turned. After everything in the boiler room has been found in good condition the refrigerating machine itself should be inspected very carefully, especially the compressors. Other important parts of the plant that must be looked after are the water supply for the condensers, the condenser water pump and the storage tank.

When everything around the condensers is found ready for service, follow up the liquid line to the liquid tank and see how much ammonia the tank contains. If there is not enough to supply the system, additional ammonia must be pumped in after the machine has been started. When ready to start the machine, after its steam cylinder has been thoroughly heated, first start the water flowing over the condenser and through the jacket of the compressor if it has any, then having made sure that the discharge valves on the compressor and, as a matter of fact, all the valves in the ammonia-discharge line into the ammonia condenser are open, the machine may be started with the bypass open. After the machine has been running slowly for about one-half minute, and everything appears to be in good condition, shut the bypass valves and open the suction valves on the compressor very slowly and continue to run the machine at a moderate speed until the back-pressure gage indicates the pressure one likes to keep on the low-pressure side.

It is necessary to be very careful when opening the suction valve after the machine has been shut down for some time, even if only for over night, as liquid is likely to form in the suction pipe above it and if allowed to enter the compressor in large quantity may break it. Next open the main liquid valve slowly, then speed up the machine. Now watch the head pressure gage, which will soon indicate if the right amount of water is turned on. The head pressure should be kept between 120 and 180 lb. when the condenser water does not exceed 75 deg. F. If a well-water or a water-tower pump is used to supply the condenser with water, it should be started before the compressor. If the compressor has an oil system, the oil should be turned on next. The gages should be watched closely for quite some time.

It is most likely that some frost will come back at first which is harmless as long as it does not enter the compressor cylinder. If the plant has a brine system, all that is to be watched is the ammonia return from that tank. The direct system for a refrigerating plant requires somewhat more attention and a trip through the rooms being refrigerated should be made after an hour or two running of the machine and the temperature in each room noted. If the room is still too warm and the condition of the frost on the suction pipe permits, a little more ammonia should be turned on, if too cold, a little should be turned off, but in each case only a little at a time; otherwise the system will get out of gear. Look after all regulating valves; note where the return from each valve enters the main return. This knowledge is of great importance and may save many trips through the rooms. When freezing back too much, one can tell at a glance from which section the frost comes, by knowing the respective section return, which will be covered with so called live frost. Often, however, when the frost comes from one room very strongly, it may back up into all the other returns and then it is hard to tell by looking at them which is the one that is doing the damage, or if there are several returns giving trouble, which one freezes back the most.

By wetting the finger tips and touching each return, the one that sticks to the fingers most readily, is the one that should be turned off some. It is good practice to have marks of some kind on each expansion valve so placed that one can tell exactly how much was turned on or off.

If one wishes to obtain the best results in a refrigerating plant the machinery should be run regularly and evenly; otherwise things will go wrong. When excessive quantities of liquid come back to the compressor, the compressor piston-rod stuffing-box will start to leak. It is bad practice to tighten up on the stuffing-box glands as the rod contracts when cold but when the frost disappears the rod becomes hot and expands again so that the leak will disappear; otherwise the packing will burn when the rod expands. When the frost comes back to the machine on account of low steam pressure which causes the machine to slow down, the best thing to do is to shut the main liquid valve for a while or stop the machine, after having pumped the low-pressure side down to zero pressure, until the steam pressure rises again.

If a refrigerating machine is to be stopped for a little while only, and the valves in the compressors are in good order, the discharge stop valves may be left open but never the suction stop valves. This should be an engine-room rule.

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Regulations for Refrigerating Plants on Board Ship

A set of instructions for German steamship companies was recently published in the *Cold Storage and Ice Trade Journal*, credit for the original being given to *Eis und Kaelte Industrie*, of Vienna. These instructions may be of interest to the stationary engineer and in part are published herewith.

The steam cylinder of the refrigerating machine will be operated with steam coming from a reducing valve at a pressure of 100 lb. per sq.in. gage, but the cylinder must be able to withstand the full boiler pressure. (This means about double the pressure stated.)

The steel valves, together with their seats, must be

removable from the CO_2 compressor cylinder, and the latter made of steel also.

The condenser coils are to be of heavy continuous copper pipe. (As ammonia would at once attack copper pipes, ammonia machines are evidently not desired.)

The evaporator (usually a submerged coil cooling brine) is to be of full weight iron pipe, continuous welded.

Where there is more than one machine, the pipe connections must allow of putting in service any one machine or all of them. The brine-circulating pumps also must be cross-connected.

The steam-driven brine and cooling-water pumps should be of ample capacity, with pistons and valve casings made of bronze.

In large installations there should be three brine lines, and in small installations two, but with an extra return line from cargo rooms that are inaccessible during the voyage.

The brine mains, which should be run as straight as possible, are to be insulated with two layers of cork pipe covering, each layer 2 in. thick and encased in a conduit packed with hairfelt.

Provision must be made for regulating and shutting off each cooling room independent of any other room.

Each cooling room, but not the ice tank, is to have its own return brine line, with a valve at the brine cooler.

All brine-cooling pipes must withstand a test pressure of 85 lb. per sq.in.

Each cold-storage room is to have its own air cooler, the side wall of the inclosing housing to be removable.

In the case of direct-expansion piping, the coils should be connected in series, so that the refrigerating medium will circulate through the coldest rooms first. Through connections must be provided to enable any one room to be bypassed.

Ordinary refrigerators and water coolers should never be piped for direct expansion. (Use brine.)

Elements of Mechanical Refrigeration

On the evening of Apr. 19, A. G. Koenig read an interesting paper on the "Theory and Application of Mechanical Refrigeration," before the Institute of Operating Engineers, New York City. The paper was elementary in character, and was illustrated by a good selection of lantern slides. Due to lack of space, only extracts from the paper will be published.

If air is compressed in a cylinder with a movable piston, its temperature rises. If this compressed air is cooled, by passing it through a surface condenser, to the temperature of the cooling water, and then expanded in a second cylinder against the resistance of a movable piston, which allows the compressed air to do work, until its pressure is down to the original pressure, the temperature of the air will fall below its temperature before compression. This cold air is now in condition to cool anything with which it is brought in contact; in other words, it may be used to absorb heat.

If a pound of air at atmospheric pressure and 60 deg. F. is compressed to 75 lb., its temperature will rise to about 420 deg. F. If this compressed air is cooled down to 65 deg. F., and then allowed to do work in expanding to atmospheric pressure, the drop in temperature will be

$$65 - (-122) = 287 \text{ deg. F.}$$

and since the specific heat of air is 0.24, the heat withdrawn will be

$$287 \times 0.24 = 68.9 \text{ B.t.u.}$$

This heat the refrigerated air will re-absorb when heated to 65 deg. F.

If instead of air 1 lb. of ammonia vapor at 20 lb. pressure and 5 deg. F. had been compressed to 120 lb. pressure, its temperature would rise to about 200 deg. F. This compressed vapor can then be cooled to 65 deg. F., but as it will also liquify at this temperature and pressure its latent heat as well as its sensible heat will be removed. The heat rejected by the ammonia vapor in liquifying is equal to the difference in temperature multiplied by the specific heat of the ammonia, 0.532, plus the latent heat at the condenser pressure, 515 B.t.u. The heat would then be

$$(220 - 65) \times 0.532 + 515 = 586.8 \text{ B.t.u.}$$

Due to mechanical difficulties, a second cylinder for expansion is never used, but the liquid is injected into the refrigerator through a pressure-reducing valve. In passing through this valve the liquid is cooled down to the evaporation temperature in the refrigerator at the expense of some of its latent heat, so that the available refrigerating effect per pound of liquid circulated is reduced to about 480 B.t.u.

It is thus apparent that air is not a good refrigerant, and in producing cold we depend mostly on substances changing their state of matter from a solid to a liquid, or from a liquid to a vapor. The so called freezing mixtures are good illustrations of the change from a solid to a liquid.

If a solid substance is dissolved in a liquid, or if two solid substances, as salt and ice, for example, are mixed to form a liquid, a certain amount of heat is required to bring about the change from solid to liquid. If the vessel in which the substances are mixed is well insulated, so that no heat is supplied from any outside source, the necessary heat must be drawn from the mixture itself, and its own temperature lowered in consequence. By mixing two parts of ice with one part of common salt, as in the old-fashioned ice-cream freezer, a temperature of 5 deg. F. can be obtained. If three parts of ice are mixed with four parts of potash, a temperature as low as —51 deg. F. is obtained. Even without the use of ice, low temperatures may be produced by mixing certain chemicals. This is a rather expensive way of producing "cold," and for the same reason, freezing mixtures are not used; so that, for commercial operation we are limited largely to a liquid changing to a vapor or gas.

Evidently for best results in refrigeration, it is desirous to hasten the process as much as possible, and, therefore, a liquid having a low boiling point, combined with a high latent heat of evaporation is selected. Several liquids have this combination, and those most commonly used are ammonia, carbon dioxide and sulphur dioxide. The boiling and condensing points and the latent heat of the above substances are as follows:

	Boiling and condensing point at atmos. press. deg. F.	Latent heat, B.t.u. per lb. atmos. press.	Cu.ft. of vapor per lb., atmos. press.
Ammonia	—27	588	18
Carbon Dioxide	—112	177	0.878
Sulphur Dioxide	+14	168	5.25

At the proper working pressures the boiling and condensing points and the latent heats are for the above substances:

	Boiling and condensing points, deg. F.	Gage press. lb.	Latent heat, B.t.u. per lb.	Cu.ft. of av. vapor per lb.
Ammonia	0	15	570	9.2
Carbon Dioxide	40	278	127	0.29
Sulphur Dioxide	14	0	168	5.25
Ammonia	90	166	488	1.63
Carbon Dioxide	86	1065	19.28	0.147
Sulphur Dioxide	86	51.5	151.5	1.27

If these volatile liquids were cheap enough, all the apparatus required for the purpose of refrigerating would be a tank or drum in which to receive the liquid, connected with a regulating valve to a sufficiently large pipe coil, in which the liquid is allowed to boil and evaporate, absorbing heat from the surrounding air or brine, as the case may be; but since ammonia, or any of the other refrigerants are too expensive for such a process, it is necessary to recover them and put them back into liquid form, so that they may be used over and over again. For the recovery of these liquids, there are, in the case of ammonia, two different methods, mechanical compression by a compressor, and compression by the use of heat in an absorption system. The author outlined the working of these two systems, but as the methods of operation of both have been recently explained in these columns, there will be no need for a repetition.

Unit of Refrigeration

The unit adopted to measure refrigeration is the heat required to melt 1 lb. of ice, which is 144 B.t.u. The unit for a ton (2000 lb.) of ice-melting capacity is, therefore,

$$2000 \times 144 = 288{,}000 \ B.t.u.$$

The commercial tonnage capacity is the refrigerating effect expressed in tons of ice-melting capacity produced by a machines in 24 hr., when running continuously under a standard set of conditions. These conditions are for an ammonia-refrigerating system 15 lb. evaporator or suction pressure, equal to a temperature of 0 deg. F., and 170 lb. condenser pressure, equal to a temperature of 91 deg. F. The above unit of refrigeration reduces to 200 B.t.u. per min. A few examples were given by the author to illustrate the practical use of the unit of refrigeration, and these may be of general interest.

Estimating Refrigeration in Brewery

How many tons of refrigeration are required to cool to 40 deg. F. 300 bbl. of wort having a specific heat of 0.95 and a temperature of 85 deg. F.? The cooling to be done in three hours.

Taking the weight of 1 bbl. of wort at 265 lb. gives

$$300 \times 265 = 79{,}500 \ lb.$$

of wort to cool. The difference in temperature is 85 — 40 = 45 deg. and the specific heat 0.95. Then

$$79{,}500 \times 0.95 \times 45 = 3{,}398{,}625 \ B.t.u.$$

which must be withdrawn from the wort.* This requires

$$\frac{3{,}398{,}625}{288{,}000} = 11.8$$

tons of refrigeration in 24 hr. But the cooling is to be done in three hours, therefore,

$$11.8 \times \tfrac{24}{8} = 94.4 \ tons$$

of refrigeration, which would be the size of the machine.

Packing-House Example

What size machine is required for a packing house killing 500 heads of beef per day, average weight of beef being 800 lb., and storage room required?

*The weight of a barrel of wort has been assumed as 265 lb. in this example. For greater accuracy, the specific weight of the wort should be taken into consideration.

Assuming 10 sq.ft. per head and a height of 20 ft., the size of chill room required would be 50 × 100 × 20 ft. high. The exposed wall surface would be

$$100 \times 20 \times 2 = 4000$$
$$50 \times 20 \times 2 = 2000$$
$$100 \times 50 = 5000$$

Total 11,000 sq.ft.

Assuming that 4 B.t.u. pass through every square foot per 24 hr. for every degree difference in temperature between 35 deg. inside and 90 deg. outside, the gain in heat would be

$$(90 - 35) \times 4 = 220 \ B.t.u.$$
$$220 \times 11{,}000 = 2{,}420{,}000 \ B.t.u. \ per \ 24 \ hr.$$
$$500 \times 800 \times 0.8 \times 65 = 20{,}800{,}000 \ B.t.u. \ per \ 24 \ hr.$$
$$20{,}800{,}000 + 2{,}420{,}000 = 23{,}220{,}000$$
$$\frac{23{,}220{,}000}{288{,}000} = 80.6 \ tons \ per \ 24 \ hr.$$

Keeping the beef in a cold-storage room 30x100x20 ft. high equals 8200 sq.ft., the gain in heat would be

$$8200 \times 4 \times 55 = 1{,}804{,}000 \ B.t.u.$$

Allowing a loss of 20 per cent. for opening doors, makes a total of 2,164,800 B.t.u. Then

$$\frac{2{,}164{,}800}{288{,}000} = 7.5 \ tons$$

Cooling of fat, three tanks of water and extra receivers for small stock requires an additional 17.5 tons which makes a total of

$$80.6 + 7.5 + 17.5 = 105.6 \ tons$$

of refrigeration.

Cooling Water per Ton of Refrigeration

From the definition of a unit of refrigeration, the refrigerating system must absorb 288,000 B.t.u. per 24 hr., or 200 B.t.u. per min. This amount of heat, plus the heat of compression amounting to about 10 per cent., is delivered to the condenser and must be carried off by the cooling water.

If the temperature of the cooling water delivered to the condenser is 75 deg. F. and of the water leaving 85 deg. F., each pound of water flowing over the condenser will have absorbed 10 B.t.u., and since a gallon of water weighs approximately 8.3 lb., each gallon of water will carry off

$$10 \times 8.3 = 83 \ B.t.u.$$

For each ton of refrigeration 200 + 20 B.t.u. are to be removed per minute, so that

$$\frac{220}{83} = 2.7 \ gal.$$

of cooling water per min. per ton of refrigeration will be required.

A more accurate method for calculating the amount of cooling water is as follows: Assume, for example, that the condensing temperature of the ammonia is 90 deg. F. its latent heat at that temperature 489 B.t.u. and that the gas goes to the condenser at 240 deg. F. The gas would be superheated 150 deg. Then

$$150 \times 0.532 = 79.8 \ B.t.u.$$
$$489 + 79.8 = 568.8 \ B.t.u.$$

per lb. of ammonia. But 0.4 lb. of ammonia are required per minute per ton of refrigeration, therefore,

$$0.4 \times 568.8 = 227.52 \ B.t.u.$$

must be absorbed, and

$$\frac{227.52}{83} = 2.74 \ gal.$$

per minute per ton of refrigeration would be required.

EDITORIALS

Consulting and Operating Engineers

Managing a business is much like playing a game wherein the value of each card must be carefully weighed. Each man in the business has a certain value and must be placed in such a position and given such influence as is compatible with his training and capacity. The duty of a manager is to pick his men so that he can apportion to each a sphere of action commensurate with his ability and to obtain a system that will work as a harmonious whole. To attain this end the spheres of action of all the men must touch and to some extent overlap.

In all industrial plants where machinery is used to turn out the product, managers have often been hard pressed to bridge over the gulf between the commercial department and the force that has charge of the machinery equipment.

Managers often find themselves at a disadvantage, when it comes to supervising the power plant, for want of the necessary training. Therefore, the sphere of action of the business man neither touches nor overlaps that of the operating man. The province of the technically trained engineer is to bridge over this gap.

The technically trained engineer studies the laws of nature underlying the principles of operation of all kinds of machinery, and takes advantage of all opportunities to observe and take a hand in their actual running. He does this to learn the difficulties encountered and to be able to apply to a useful purpose the special knowledge that he has been fortunate enough to acquire. It is not his desire to take the place of the engineer or encroach upon his work, for their spheres of work are entirely different, and if either goes beyond his limits he is at once beset with all kinds of anxieties and troubles.

It is for these and other good reasons that the supervision of operation of all large power houses and industrial plants by technically trained engineers has become desirable. Wherever a plant or group of plants is large enough to warrant the expense, trained engineers are employed. Where the size of the plant does not warrant the expense it is advisable to retain the services of a consulting engineer who has made that particular brand of engineering or manufacture his life work. In this way his expense can be divided between a number of manufacturers.

The ice making and refrigerating industry, although it has ample use for them, has not employed technical men to any great extent. The reasons are that there are but few technically trained men available, that most of the owners and managers of such plants do not appreciate the value of such services and that the operating men often do not seem to be aware of the benefits to be derived from a free coöperation with consulting refrigerating engineers. Competition has made economy of plant operation a prime factor, and lack of technical help or advice is directly responsible for many failures of owners to realize the profits which otherwise would be theirs.

Operating engineers sometimes labor under the false impression that they are injuring their prestige if they do not pretend to know as much as anyone else on all phases of their work. When such an engineer gets into trouble he looks to the manufacturer of the machinery he runs to help him out, but it is hardly fair to expect a firm to employ a sufficient number of skilled men to take care of and watch the operation of every plant they have equipped. It must be said in defense of the engineer that owners and managers have contributed to this false attitude because they do not appreciate the difficulties of the situation and expect an unreasonable amount of knowledge and experience from their engineers.

The work of the consulting engineer then is entirely different from that of the operating engineer. Each one has a certain allotted work to perform and whenever he transgresses too seriously on work outside of his province there is trouble ahead.

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Right Men in the Right Place

Success comes to the men who fight on where others give up and allow matters to take their course. Some engineers do not know the meaning of defeat, but go on overcoming obstacles instead of sitting down and saying, "It is of no use, it cannot be done." One power plant in a Western state, that survived the ravages of wind and water, was kept in operation with a shutdown of only about fourteen hours, because those in charge made a stand and fought.

The high wind which preceded the flood completely demolished a brick, high-tension booster station and tore down the high-tension lines. The interurban trolley service was disabled until repairs could be made or temporary arrangements made. The latter were adopted and electrical energy was supplied from a five hundred and fifty-volt feeder, twenty-six miles long. Then light-weight cars were run to keep the drop in voltage as low as possible. It seems simple now, but how many managers would have adopted this method of keeping the trolley line in operation?

This problem was hardly solved before the power plant was menaced by the rising river water. Although the engine-room floor had been built four feet above the highest water level recorded, before the flood subsided the water level had risen three feet above the floor of the generator floor. But, owing to the ability of those in charge to grasp the emergency situation, the plant was undamaged when the flood subsided.

Here was a case requiring decision and prompt action if the power-plant machinery was not to be damaged by water. How was it to be done? Could the water from the rapidly rising river be prevented from flooding the basement, auxiliary machinery, the generator floor and main units?

The general manager and engineer decided that the basement walls had to be protected from the pressure of

the water to prevent them from being forced in. As there was but little time, about one hundred men were put to work to build a wall of sand bags around the building to deflect the river current, and by hard work the sand-bag dike was kept at a greater height than the rapidly rising water.

As another precaution a temporary brick wall was built in the interior of the turbine room at either end, and the doors were sealed with sand bags. This was to prevent the water leaking through the sand-bag dike, getting into the room.

Then the water in the basement had to be removed, and there were no spare pumps. Did they throw up their hands and say "It cannot be done?" Hardly. They disconnected the centrifugal-circulating pumps and used them, and the exciter units were run to light the plant while the work was going on. When there was time to make different arrangements, reciprocating pumps were procured, and connecting the circulating pump to the condensers the plant was started with but a short shutdown.

Here is a typical case of what the right men in the right place can do. Had the men in charge of this plant been of the "give it up" caliber it is probable that extensive repairs would have been necessary to put the plant in operating condition, in addition to the inconvenience and loss the necessary shutdown would have occasioned.

Troubles of the Trouble Man

What is more aggravating, when retained by a plant to make improvements and reduce costs and just about to accomplish something worth while, than to be denied that satisfaction by an order to cease work until the management gets ready to have it continued? If you have never had this experience as an expert engineer, you can appreciate the feeling by recollecting your boyhood days, when father called you to hoe potatoes just as you were finishing the best kite you ever made.

Putting an uneconomical and rapidly deteriorating, though, perhaps, comparatively new, plant into economical and stable condition is difficult enough without being hampered by a management that is suspicious when it ought to be grateful. Under the most favorable conditions you are likely to offend someone who is "in right." It may be the chief engineer, master mechanic, manager or perhaps a consulting engineer friend of the president. You do not know until the inevitable "clash" occurs, and that happens when you condemn a steam main which is a veritable water leg, and which may have been designed by any of the aforementioned individuals. It may be that you make six boilers do the work for which the master mechanic or chief engineer used twelve. At any rate you are "no good" and the "in right" individual immediately seeks to convince the management that you are all you should not be. Too often he succeeds.

As an example of pitiable ignorance or contemptible obstinacy we recall an expert engineer who, in the schedule which he left with the company as a guide for the most economical operation of its plant, specified three pints of oil per day of twelve hours for each engine. The plant normally operated twelve hours per day and the schedule was made out on that basis. One day afterward a long letter came complaining bitterly because the specified three pints of oil was not enough and that a few engines had been nearly ruined.

Investigation revealed that the plant was operating eighteen hours per day. As the expert engineer tells it, the chief engineer of that plant did not consider his intelligence insulted when a new schedule arrived which specified the oil consumption for each hour's operation over the twelve-hour day.

Co-operation in Power-Plant Work

The everyday work in large power plants is usually performed without waste of time or effort because such work must be done in an orderly manner. Each knows what his day's work includes, hence the men need no special instructions so long as their work does not depart from the regular routine. But in emergencies or when extensive or unusual repairs are to be made, confusion and loss of time often follow an order for such work, because the one who issues the order does not sufficiently coöperate with those that are to do the work.

For instance, consider changes in the steam main of a large plant that requires a change over from one steam header to the other. One "fitter" and a helper are sometimes put on this job, which is long and hard, while, perhaps, at the same time, other fitters and helpers are sent to make insignificant repairs that one man could complete in a few hours. Should something happen—and something usually does—to delay the men working on the steam main it would undoubtedly mean overtime work for them and perhaps hinder the plant's operation.

There should be a general "getting together" prior to doing such work. Let the man who is to direct the work give full particulars to the one who is actually to do the work. The latter should then see to it that he has the required number of assistants and that each of them has his particular part of the work laid out for him.

When a repair job is to be done or new work commenced, the man in charge should outline to his helpers the manner of procedure so that they may have a good idea of what next is to come, as the job progresses.

Unpreparedness

Some large manufacturing establishments along the Atlantic coast and up the tidewater waterways were caught napping recently, when the outgoing tide dropped the water level to the lowest point in thirty years. The tide went out so far that the ends of the condenser circulating-water pipes were uncovered, depriving the engines of condenser service, which is necessary to enable them to carry their loads.

The situation was indeed serious in some plants because the tide remained out for a considerable time. Those plants not prepared for such emergencies paid dear for their unpreparedness.

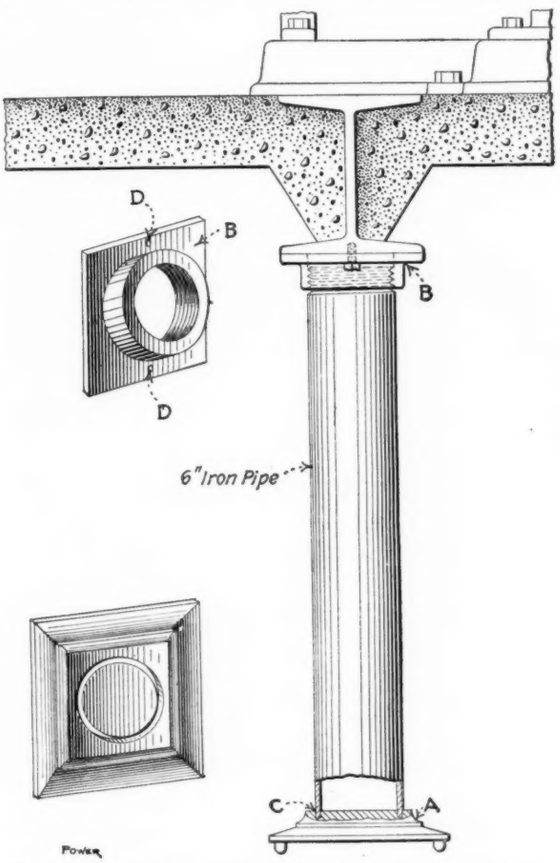
The same is true of plants where units of one kind or another are crippled, not necessarily seriously, but enough to make problematical their continuity of service. The required repairs are not made until these several minor weaknesses produce a "general debility" as it were, of the entire plant. That is another kind of unforgivable unpreparedness.

READERS WITH SOMETHING TO SAY

Adjustable Support for Generator Foundation

The sketch shows a steel post that was used to strengthen the cement floor on which a new generator set was to be installed. Five of these were made and set under the I-beams that supported the cement floor.

The posts were of 6-in. iron pipe cut to length and threaded on one end. Plates *A* and *B* were of cast iron, *B* being threaded for the pipe or post, while the plate *A*



DETAILS OF ADJUSTABLE SUPPORT FOR GENERATOR FOUNDATION

was cast with a groove *C*, which was of the thickness and diameter of the pipe. Before placing the post under the I-beam, plate *B* was screwed on the threaded end of the pipe as far as it could be turned by hand; the post was then set in the groove in plate *A* and holes were drilled and tapped in the I-beam. Also holes were drilled in plate *B* at *DD* to correspond with the holes in the I-beam. The post was then set so that the holes in the beam and those in plate *B* came in line; bolts were then inserted, raising the post up and leaving a clearance of ¼ in. between the bottom of the groove in plate *A* and the end of the pipe. To bring the pipe and plate together a pair of chain tongs were used to unscrew the pipe a few threads from the top plate, thus making the post tight against the floor and I-beam.

J. B. LINKER.

Charlotte, N. C.

Condenser Repairs

One of the valve stems on the lower deck of a bucket condenser worked loose and dropped through the opening in the valve seat. As it was impossible to get the stud without removing the valve seat, which there was not time to do, a new stem was the best solution of the trouble.

A common bolt was taken of suitable size and length, and a piece of pipe cut to fit over the bolt and long enough

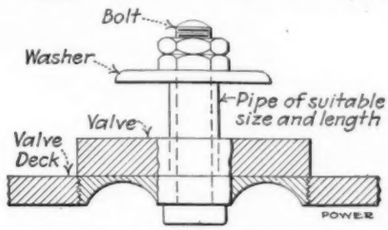


FIG. 1. STUD AS REPAIRED

to allow the valve to raise as high as it had originally. The pipe served as the shoulder on the original valve stem, so that the valve guard could be screwed down against it. The illustration, Fig. 1, shows the stud as it was repaired. A large washer on the valve guard against which the pipe bushing and nut came, permitted securing the bolt in a firm position.

In Fig. 2 is shown how a hand pump was connected to

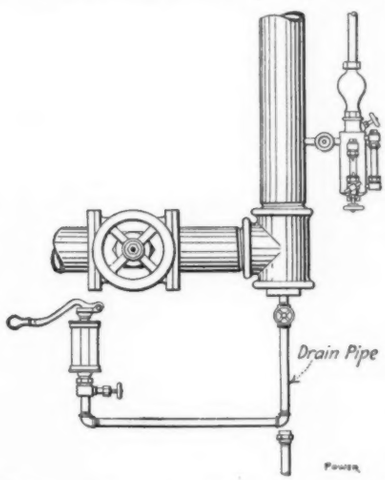


FIG. 2. PIPING OF HAND OIL PUMP

the steam pipe through which the cylinder was lubricated until repairs could be made to the lubricator connection.

The trouble was caused by the breaking of the ¼-in. iron-pipe connection from the lubricator at the main steam pipe. A hand oil pump was taken from the main

engine and, after disconnecting the drain pipe at the union, was attached as shown and oil pumped to the cylinder until the engine could be shut down at the end of the week.

Water to a barometric condenser was supplied through a 5-in. pipe which extended perpendicularly from the pump through the engine-room roof, ran horizontally 4 ft., and then perpendicularly to the condenser head. As

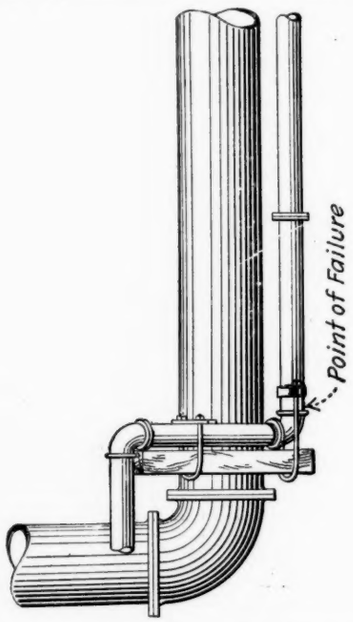


FIG. 3. HOW THE PIPE JOINT WAS HELD TOGETHER

the pipe line was not properly connected, one night it pulled apart at the ell, as shown in Fig. 3, the pipe having been screwed in not more than three threads. As the day load was heavier than the night load it was impossible to spare the condenser and it was decided to repair the leak that night to tide over until such time as a permanent job could be made.

Some pieces of 1x1¼-in. iron were secured long enough to form a U-bend around the wooden supporting member and to pass through a cross-piece on top. A second clamp was used as shown on the vertical pipes.

When the clamps were ready a piece of 4x4-in. wood, of sufficient length to reach from the horizontal pipe, but beyond the second vertical pipe, was placed as shown. This was held by one of the U-clamps, the outer U-clamp passing through a band clamp on the vertical pipe, as shown. The nuts on the U-bends were tightened which drew the vertical pipe into the tee and supported it in place. Then pine plugs were driven in around the pipe and followed up with lead, thus stopping the leak.

JOHN J. RAMSEY.

Wellington, Kan.

Better Attention, Better Service

The engineer having a license should be absolutely in charge of the steam plant. Examiners of engineers, when they visit a plant, should ask the owner or manager who is held responsible for the plant. If the master mechanic is, find out whether or not he has a license. If not, he should be required to have one, or not have anything to do with the plant. As the law is now, one gets a license and the state holds him responsible for any accident in the plant. Should any occur, it would probably deprive his family of a livelihood, and still he has no jurisdiction over the plant. I do not want to have the license law enforced as a farce.

If engineers want to progress, they should receive more questions regarding breakdowns, and how to make repairs without calling in outside help, which often means a loss of time to their employers. The engineer should be granted a license on the amount and kind of experience he has had. In looking over the field, it will be found that many engineers have received their license by being tutored in engineering schools which have sprung up "like mushrooms in the night."

How many engineers enter their engine rooms on a Monday morning, thinking, "Now, what can I do to help my employer in every way, not only in saving in the power plant, but by giving him the greatest possible speed to get the greatest production?" I do not think that many of them give it a thought that one or two revolutions lost on the engine means a great loss to the employer.

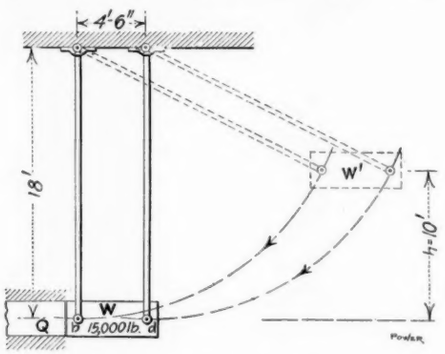
When I was a young man, having charge of a cotton-mill plant, I never thought of leaving the plant Saturday night, unless I went into the cloth room to find how much the production was for that week. It showed to my employer that I was interested in the entire plant. I never had to ask for an increase in pay. It was always coming. If engineers would devote more attention to making their plants paying investments, many small plants, which are now idle, would be operating.

GEORGE H. DIMAN.

Lawrence, Mass.

Best Form of Link

A mass of iron, weighing 15,000 lb., suspended by four links, each 18 ft. long, like AB and CD, as shown in the accompanying sketch, is lifted by a magnet to the position W' through a vertical height of $h = 10$ ft. After being raised to this height, the magnet releases the



weight and, upon arriving at the lowest point of its travel W, the weight strikes a resisting mass Q.

Assuming that the weight moves a distance of not more than 2 in. after impact, and neglecting friction of the center pins, what section of link would be best suited to withstand the stresses due to the centrifugal force of the weight and the impact of the weight itself?

Philadelphia, Penn. S. N. BOWMAN.

[Answers from readers would be appreciated.—EDITOR.]

QUESTIONS BEFORE THE HOUSE

The Allis-Chalmers Engine

Referring to the article under the above title, in the Jan. 21 issue, signed by Richard H. Rice, I would state that I was the engineer in charge of the Corliss engine department of the Allis-Chalmers Co. during the time that their new engine was designed, built, tested and placed on the market. I have no apologies to offer anyone for the work done while I was in charge of that department.

The engine is not an exact copy of the Rice-Sargeant engine as stated. The Allis-Chalmers Co. has built double-ported valves for many years. The steam valves are located no nearer the cylinder than they have been for over 30 years on all engines with valves in the corner of the cylinder. The exhaust valves have been placed higher than in the old engine to reduce the clearance. The same thing has been done by several builders of Corliss engines. The Allis-Chalmers Co. has been building engines with both steam and exhaust valves in the heads for many years, which design gives less clearance than is possible with the design for which Mr. Rice claims his former company was the pioneer.

I wish to call attention to Mr. Rice's statement that the use of the wristplate motion limits the cutoff to from 0.4 to 0.5 stroke and would ask Mr. Rice what the wristplate has to do with the cutoff. The Allis-Chalmers Co. has built double-eccentric engines both with and without steam wristplates, according to the purchaser's desire, and has been doing that for many years. The first man to apply separate eccentrics to actuate the steam and exhaust valves on Corliss engines was the late William E. Crane, while he was operating engines at Waterbury, Conn. The Green engine, which was built before the Rice-Sargeant engine, in the same shops, had two eccentrics and no wristplate.

Referring to the comments on the new Allis-Chalmers Co. governor, I would state that I believe it to be the most powerful, sensitive and nearest fool-proof of anything that has been designed up to date. The advertising matter sent out by the Rice-Sargeant Co. would indicate that they had abandoned the Rites inertia governor. The picture of their new governor looks very much like the governor on the Allis-Chalmers Co.'s engine in the Metropolitan Life Insurance Co.'s building in New York City. On the acceptance test, the regulation of the Allis-Chalmers Co.'s engine was far superior to the Rice-Sargeant engines, which were equipped with the Rites inertia governor. An examination of the Allis-Chalmers governor and the Rites inertia governor, mentioned in Mr. Rice's letter, will convince any engineer that the former has less parts; therefore less complications and on account of its being entirely inclosed can be flooded with oil which greatly prolongs its useful life.

Ample provisions have been made to take care of the expansion between the cylinder, frames and foundations. I note that Mr. Rice refrains from saying anything about the Allis-Chalmers Co.'s frame, self-adjusting main bearing, oil guards and other points that are strictly uptodate but concedes *their* engine was designed 19 years ago. Finally, would say that I am not with the Allis-Chalmers Co., am under no obligations to them except to wish the company the success it deserves.

R. D. Tomlinson.

Danbury, Conn.

Mr. Flannery's Feed-Water Heater

Some statements in Mr. Flannery's letter concerning the trouble with his feed-water heater I do not understand. He says that the heater is much too large and, in proof of this, says that when he runs the pump fast he gets a temperature of 200 deg.; but when running slow only gets a temperature of 190 deg., and he also says that if the heater was smaller, the water would move faster and he would get a higher temperature.

I fail to see just how he accounts for this. I believe that the reason is that he does not get enough steam to heat the water over 190 deg., but when running the inefficient "steam eating" pump at higher speeds, he gets more steam in the heater, and, consequently, heats the water to a higher temperature. The slower the water moves through an open heater, the hotter it will get, up to 212 deg.

He also states that he has 4 ft. of water below the suction pipe and only 14 in. above it that is available for use if the supply is interrupted. If he will examine the inside of his heater, I think he will find a hood covering the suction opening so that he can pump out the greater part of that 4 ft. of water, or, if not, there is, or should be, a bypass from the lower part of the chamber to the suction pipe. Further on, he states that when the filter gets dirty he has trouble in regulating the water supply. This, I consider, a good proof of the efficiency of the filter. If it gets clogged up in a short time, it shows that it is effective in removing the foreign matter, and his trouble lies in that he does not clean it often enough. I think it would be much more desirable to clean the deposit out of the heater than out of the boiler.

His trouble seems to be due chiefly to lack of steam to heat the water; possibly only a small part of the steam goes to the heater, the rest being used for other purposes. I have operated some ten or twelve different heaters and, although I found some that would not heat the water as hot as they should, there was usually some reason other than the design to account for it.

J. C. Hawkins.

Hyattsville, Md.

While rebuilding a steam plant under my supervision, it was decided to install an open feed-water heater. The one selected was of the through type, i.e., all of the exhaust entered the side and passed out of the top. The feed water entered the top, falling into a cast-iron pan which overflowed into a set of cast-iron trays, from which

it fell to the filtering material, through this to a chamber in the bottom of the heater. The hot-water outlet was at the lowest point of the hot-water chamber.

We set the heater so that the bottom of the hot-water chamber was one foot above the pump suction. Mr. Flannery can overcome part of his trouble by raising his heater and putting in a bypass from the lowest point to his suction line, keeping the piping always below the outlet. This would give unfiltered water, but it would be better in an emergency than no water at all.

In operating our heater, we soon found that a two weeks' run choked the trays with scale, besides lining the interior with scale ¾ in. thick. The trays "froze" in the guides so firmly it was very hard to remove them for cleaning. To overcome this, we made strap-iron hangers to fit 2-in. pipe and long enough to slip into the grooves in place of the trays. These hangers were so made that pieces of pipe cut as long as the heater was deep inside, would be 1½ in. apart in the row and the rows staggered when placed in position. There were six rows and two hangers for each row. It was a quick job to remove, clean and replace these pipes.

We had much trouble using coke for a filter material as small particles washed through and filled up the outlet pipe. Coarse marsh hay, or "swamp grass" as some call it, makes the cleanest and quickest filter material we have ever used.

While Mr. Flannery's heater is too large for his boiler capacity, I do not believe this should materially affect the temperature of the water if the heater was arranged differently. With us the temperature never varied, no matter how much or how little water was being passed. I believe the cause of the drop in temperature is due to a large quantity of water being held ahead of the filter in the coldest part of the heater, where it is subject to excessive radiation before it is filtered. If the water was held directly under the trays, where it would be in the hottest part of the heater, it would stay hot. Naturally, the faster the water travels through Mr. Flannery's type of heater, the hotter it will be, as it is subject to that much less radiation.

G. Anderson.

Cresco, Iowa.

Operating Costs of Hydraulic vs. Electric Elevators

The writer was much interested in Mr. Waldron's contribution on the above subject, in the Jan. 28 issue. If we could save coal in heating buildings by first using the steam for elevator service, and thus taking the exhaust for heating, nearly all buildings would soon be equipped with elevators, running up and down automatically, to reduce the coal bill.

Mr. Waldron must have made some mistake. Perhaps the winter the electric elevators were used was more severe than the previous one when those of the hydraulic type were used. Perhaps serious leaks that allowed the escape of many B.t.u. may have occurred during the second year. Faulty traps, scaled boilers, scaled feed-water heater or many other things might have caused the increase in the coal consumption over what it was when the steam was used for the elevator pumps before being admitted to the heating system.

If there are steam boilers on the premises, it will prove cheaper to use the steam for the elevators and the exhaust for heating than it will to use the steam for heating and buy electric current for the elevators, unless the electric power is furnished very cheaply. On the other hand, a given amount of steam will furnish more heat to the rooms if used direct, than if first used for some other purpose.

From Mr. Waldron's letter, I conclude that the central station was carrying all the lighting load and all the power load, excepting that for the elevators. If this is so, it would seem reasonable to either give the central stations the elevator load also, or take all the load away from them. Mr. Waldron does not say whether or not the boilers were shut down in the summer, after the new elevators were installed; but if they were not, and low-pressure steam were necessary the year round, it seems difficult to see how the central station ever got hold of that building in the first place.

John Bailey.

Milwaukee, Wis.

Available CO_2 Percentages

In his letter "Available CO_2 Percentages," in the Apr. 15 issue, A. Pohlman brings up a question that probably has occurred to many engineers. The only purpose of this letter is to call attention to an error in an otherwise excellent article.

As Mr. Pohlman states, perfect combustion of pure carbon in air would give 21 per cent. CO_2 and 79 per cent. nitrogen and this would require 11.6 lb. of air per pound of carbon or, at ordinary temperature and pressure, 152.7 cu.ft. If, however, the fuel contained only 70 per cent. carbon and the remaining 30 per cent. were ash, the gas analysis for perfect combustion would still be 21 per cent. CO_2 and 79 per cent. nitrogen, but the amount of air required would be only

$$0.70 \times 11.6 \text{ lb.} = 8.12 \text{ lb.}$$

of air, or 106.8 cu.ft.

Most fuels, however, contain hydrogen in varying quantities and this is what does affect the percentage of CO_2 that can be obtained even with the best firing, as this hydrogen combines with the oxygen of the air to form water, which in the furnace gases exists as superheated steam, but which, when a sample is drawn off for analysis in the Orsat apparatus, condenses and disappears, as far as that analysis is concerned.

For instance, take an extreme case. Pittsburgh natural gas, contains by volume, methane (CH_4), 89.3 per cent.; ethane (C_2H_6), 8.5 per cent., and nitrogen (N), 2.2 per cent., or by weight carbon (C), 73.4 per cent.; hydrogen (H), 23.1 per cent.; nitrogen (N), 3.5 per cent.

With perfect combustion this gas gives an analysis of 12 per cent. CO_2 and 88 per cent. nitrogen. Fuel oil also shows a low maximum possible percentage of CO_2, 15.7 per cent.; nitrogen, 84.3 per cent., for an oil containing 87.8 per cent. carbon and 12.2 per cent. hydrogen by weight.

Most coals, particularly those sold in the East, show much higher maximum possible percentages of CO_2, as the available hydrogen, i.e., hydrogen content after subtracting that already combined with the oxygen in the coal and existing as water of constitution, is much less

and give maximum percentages of between 18 and 19 per cent. CO_2, the remainder being nitrogen. The writer has obtained results checking the above figures in practice when the air supply happened to be just right to give perfect combustion.

The surest guide to the working of any furnace is to analyze the flue gases for carbon dioxide, oxygen and carbon monoxide, as by this method complete information is obtained and nothing is left to guesswork. The magnitude of the unnecessary losses can then be easily ascertained as these are in direct proportion to the ratio of the unnecessary or excess air above that required for combustion to the amount necessary to give complete combustion with the coal and the temperature and also to the ratio of the carbon monoxide to the sum of the carbon dioxide and carbon monoxide. The first of these, the excess air loss, does not bear a direct relation to the percentage of CO_2 but increases at an increasing rate as percentage of CO_2 decreases. For instance, with 14 per cent. CO_2, a decrease of 1 per cent. CO_2 and a corresponding increase in oxygen would indicate an increase in air excess from 36 to 47 per cent., whereas at 7 per cent. CO_2, a decrease of ½ per cent. in CO_2 means an increase in air excess of from 180 to 202 per cent., and a decrease of 1 per cent. in CO_2 an increase in air excess from 180 to 226 per cent.

The excess air percentage can be calculated for any gas analysis from the formula.

$$\textit{Percentage excess air} = 100 \times \frac{0.265\ \textit{percentage nitrogen} - \textit{per cent. oxygen}}{\textit{percentage oxygen}}$$

The carbon-monoxide loss, due to the escape of unburned gases up the stack, depends, as stated before, on the ratio of the percentage of carbon monoxide to the sum of the percentages of carbon monoxide and carbon dioxide. Thus it will be seen that, when the percentage of CO_2 is low, small percentages of carbon monoxide may mean a serious loss, whereas, if the percentage of CO_2 is high, such a small fraction of the total carbon is escaping unburned that the loss is unimportant. Usually, however, any percentage of carbon monoxide that can be unmistakably detected by an Orsat, say, 0.3 to 0.5 per cent., is more than should occur and a sufficiently thinner fire should be carried to do away with it, as the loss due to the necessary increase in air excess will usually be much less than that due to the carbon monoxide.

In water-tube boilers with horizontal tubes and vertical baffles the presence of carbon monoxide can be detected at once by watching the cracks in the lower part of the front baffle through the soot blow-holes in the second pass, as blue flames appear there as soon as carbon monoxide is formed, and after a little practice the percentage present can be estimated within reasonable limits from the length and thickness of the flame.

The relative importance of these two losses depends largely on the flue temperature. Where this is low, as in boilers, a comparatively large increase in percentage of air excess will cause less loss than a small increase in carbon monoxide while in high-temperature work, such as in iron and glass furnaces, the losses due to air excess are much more serious than those due to unburned gases, on account of the much greater effect they have in lowering the temperature of the furnace.

In taking samples of flue gas it is important, if it is desired to check the work of the fireman, to see that the sampling tube is so arranged that it draws from a well mixed body of gas coming from the fire and undiluted by air. A boiler setting in good condition should not increase the air excess in the flue gases more than 30 to 50 per cent. between the middle of the first pass, and the flue neck, with the boiler running at or about rated capacity, and if it is found impossible to get gas analysis containing more than 8 to 10 per cent. CO_2 when the fire has been put in good shape and the sampling connections, etc., are known to be tight, the setting should be carefully gone over for air leaks and repaired. Then the maximum economical percentage of CO_2 to carry will be that at which, with a level fuel bed of the proper thickness for the draft, traces of carbon monoxide begin to show. Always care must be taken that, in endeavoring to obtain a good gas analysis, the fire is not so thickened that the boiler is nearly banked and the capacity seriously reduced, as this has been known to occur.

H. D. Fisher.

Newton Highlands, Mass.

Care of High-Vacuum Apparatus

Referring to the article under the above title, in the Dec. 31 issue, I would offer the following comment:

Relative to the condenser log for a 2000-kw. turbine, dated July 13, 1911, the most important figure appears to have been overlooked, the barometer reading. Without this reading, a fair criticism is impossible, and I can only assume that the vacuum readings given refer to a 30-in. barometer reading. Where were the air-pump discharge and hotwell-line readings observed? It is not stated that a separate hotwell pump handled the condensate, so the assumption is that a suction-valveless air pump handles both the air and the condensate. If so, one would expect the condensate temperature to lie somewhere between the temperature of the circulating-water inlet and outlet, whereas the figures indicate that the condensate kept within 1 deg. of the steam temperature and the nearest it approached the circulating-water discharge temperature was 4 deg. above. At 9 o'clock p.m., it was actually 11 deg. hotter than the discharged circulating water.

We all endeavor to withdraw the condensate at as high a temperature as practicable, commensurate with reasonable proportions for air pumps, so one is inclined to wonder what special means were adopted in this instance, inas much as the air pumps do not appear to have been too well proportioned in the way of displacement efficiency. The log states that at 9:30 p.m., the air-pump plunger-rod glands were leaking. From a comparison of the steam temperatures given with the vacuum logged, this leak would appear to have been more excessive at 6:30 p.m.

At 6:30 p.m., the load was 900 kw.; steam temperature 90 deg., which corresponds to a vacuum of 28.58 in., whereas the vacuum logged was 28.4 in., leaving a vacuum of 0.18 in. to be accounted for by the pressure of air.

At 9:30 p.m., the load was 1865 kw.; steam temperature 101 deg., corresponding to 28.011 in. vacuum. The vacuum logged was 27.9 in., leaving a vacuum of 0.111 in. loss, due to air in the condenser.

This letter is written in an honest attempt to understand this part of the published article.

Goodmayes, Eng. W. Vincent Treeby.

Putting New Valve Stems in Corliss Engine

In the Jan. 28 issue, H. W. Lee asks for information in regard to putting in Corliss valve stems. Although he does not say so, I suppose he will get them from the engine builder, in which case all that he will have to do is cut the keyways, as it will not be necessary to dismantle the valve-gear.

To take the old stems out, remove the packing from the stuffing-boxes, take off the back bonnets and pull the valves back with an eye-bolt, then draw out the keys and push the stems back into the valve chamber. If the new stems are of proper dimensions, all that is necessary is to dress down the T-head of the stem, which is left a little large so that it can be made a tight fit in the slot in the end of the valve. One of the most simple ways of cutting a keyway in a valve stem is the following:

The new stems are turned up in the machine shop and then put in the engine. The valve is put in and the bell crank fitted on. The valve is then set with the proper amount of lead and is held from turning by inserting a piece of cardboard between the valve and the bonnet, which is drawn up tight. The wristplate is then put in its central position and the valve rod screwed in about one or two threads. To mark the stem for the keyway in the bell crank, a combination square with a center head is placed on the end of the stem and bell crank and a line is drawn through the center of the keyway and center of the stem; then two other lines are drawn parallel to the center line to mark the width for the keyways.

The ends of the valve stems and the valve bonnets should be marked with a center punch to identify them. The stems are then taken to the shop and three lines drawn on the shaft with a keyseat square, to correspond to the lines drawn on the end of the stems. A line is drawn to locate the depth of the keyseat or keyway. The length of the keyway is then measured and a center punch mark made at this point on the center line. The stems are then taken to the drill press and a hole of the required depth drilled at the end of the keyways. Then the stems are ready to be put in the shaper, and the keyway cut to the proper width and depth.

When a planer or shaper cannot be reached, the keyway may be cut with a cape chisel, making it a little narrower than the required width and dressing it out with a file to the exact dimension. There are other ways of locating the keyways, but this, I think, is the best.

After the new stems are in, one should check up the valve setting, because it may have been changed while the repairs were being made. After getting the engine in operation, apply the indicator and make such minor adjustments as may be required.

J. C. Hawkins.

Hyattsville, Md.

Having renewed the stems in a large Corliss engine, I will state my method, hoping it will assist Mr. Lee.

The first proceeding is to remove the back bonnets of the valves. Considering first the steam valves, hook up the valve, the stem of which is to be renewed, and move the valve-gear in the direction it takes when running until the central marks on the wristplate, hub and trunnion are line and line; now make a light scratch mark on the back end of the valve and chamber. (It will be best to make this mark where it will not be confused with the marks showing the working edge of the port and valve.)

Next remove the valve from the chamber and, after drawing the key, the old stem may be removed through the valve chamber, which saves the work of removing the front bonnet or yoke.

The new stem is now inserted in the same manner and the bell crank, carrying the latch-block and dashpot connection, slipped on the new stem. With the block and hook engaged again, move the wristplate to the central position; insert the valve in the chamber, placing the T-head on the valve stem in the slot in the end of the valve. Turn the valve and stem until the scratch marks previously made are line and line. A scriber may now be inserted in the keyway in the bell crank and the position of the keyway marked on the new stem, which is now taken out and the keyway cut, after which the gear is again assembled, the key driven in, the valve hooked up and the wristplate brought again to the central position, when the scratch marks on the end of the valve and chamber should be line and line, if the keyway has been properly cut. If they are not line and line, change the valve rod enough to make them so.

If the valves are heavy, it will probably be easier to remove the front bonnets in taking out the stems.

The same method is followed with each of the valves.

When bringing the wristplate to the central position, it will be well to bring it in the same direction each time it is centered for the separate valves, as this insures the lost motion in the valve-gear being taken up alike and lessens the possibility of having to change the valve rod.

I changed four stems on a Corliss engine in this manner and, in only one instance, was it necessary to make any change in the valve rods, as the setting of the valves was not altered.

C. B. Hudson.

Malden, Mass.

What Is a Bleeder?

In Inquiries of General Interest, for Mar. 18, 1913, was the one "What is a Bleeder?" Although the answer given is correct, it may not be the one sought. Another type of bleeder is a valve that opens into the condenser, and is used mainly in marine power plants to reduce the steam pressure on the boilers, thus preventing them from blowing off. The writer has seen them used only on surface condensers.

There is one fault with this bleeder. If the fireman or stoker knows where it is, but does not know when it should be used, he might do some damage. The writer was in the engine room of a steamer when a fireman came in and picked up a T-wrench (the valve was below the grating) and started to open the bleeder, and being asked what he intended to do, he stated that he wished to reduce the steam pressure as it was at the blowing-off point. The boat at this time was tied up at the dock and all pumps stopped (that is, circulating pumps).

After explaining the bleeder and when it should be used, I started the circulating pump, and cautioned him never to open the bleeder while the pump was stopped, as he might get a dangerous pressure in the condenser.

New Bedford, Mass. L. J. Olliver.

INQUIRIES OF GENERAL INTEREST

Leaking Piston—When steam leaks past the piston how can it be told whether new rings will be enough or whether the cylinder should also be rebored?

A. P.

If the cylinder is not seriously scratched or cut, and careful calipering at various points shows no greater variation in the cylinder diameter than $^3/_{64}$ in. (for a moderate size cylinder), the cylinder need not be rebored.

Lead Boiler Manhole Gaskets—What is the objection to the use of a lead manhole gasket below the water-line of a boiler?

W. M.

Because such gaskets, being inelastic, are permanently compressed by expansion and contraction. Thus leaks are likely to develop unexpectedly and without giving warning of their existence until the water in the boiler has fallen to a dangerously low level.

Boiler Feeding Under Pressure—What is meant by the term "under pressure" used in connection with water delivered to feed boilers from an elevated tank?

H. V. W.

When feed water is delivered to a boiler by tank or reservoir pressure which is sufficient to overcome the boiler pressure without using a pump, injector or other feeder, the boiler is said to be fed "under pressure," i.e., only the pressure it has as delivered to the plant.

Impregnating Wire Coils—Explain the process of impregnating the coils of a 15-hp. motor for underground use?

H. V. W.

Such coils are impregnated with a waterproofing compound (mainly rubber) forced in under pressure by first exhausting the air from the coil. The coil is put into a sealed iron tank from which the air is exhausted until a high vacuum is obtained. The compound is then introduced and a high pressure again admitted to the tank interior and the impregnating compound is forced into all the interstices of the coil.

Connecting Ammeter—On which side of a circuit should an ammeter be placed, i.e., on the positive or the negative?

H. R. L.

In connection with a compound-wound generator, which is run in parallel with another machine, the ammeter should always be placed on the opposite side from that in which the series field and equalizer connection are inserted. The equalizer connection is always made between the brush and the series field, but the latter may be on either the positive or the negative side. The object of placing the meter on the opposite side from the equalizer is to prevent it from recording currents from other machines.

Lightest Gasoline Engine—What is the lightest engine per horsepower that has been built and how does it compare with other engines?

C. J. J.

The seven-cylinder Gnome, an aëroplane engine, is the lightest, weighing only 3½ lb. per hp. This refers to the engine proper and does not include the weight of the necessary auxiliary plant as gasoline tank, radiator, etc. Automobile engines usually weigh 18 to 24 lb. per hp., but this weight includes a flywheel, whereas the Gnome has none. A two-stroke-cycle marine Diesel engine of Nurnberg type, weighs 50 lb. per hp. Stationary oil engines weigh up to about 270 lb. per hp.

Algae in Water—What causes a green moss-like substance to grow in a water tank, and how can it be prevented? The tank is open to the atmosphere and and water is pumped from a deep well, and is used for laundry and drinking purposes.

A. A. G.

The growth referred to is of vegetable origin and of many natures, but all generally classified as algae. They have no harmful effect on water for any purpose; the principal objection to their presence in water is their tendency to clog piping and plumbing. Algae are far more likely to occur in water drawn from deep wells than from surface waters. The best way to discourage the growth is to keep the water in tanks from which light is excluded.

Coal Consumption—We have three 150-hp. water-tube boilers used for heating and drying and carrying 50-lb. pressure. Is not 2000 tons of coal per year too much to be burning?

O. W. G.

The horsepower rating of the boilers is no criterion of the amount of coal burned. The only way to prove the economy is to determine the amount of water evaporated in relation to the amount of coal burned. This must be done by an evaporative test. If the boilers are found to be evaporating 7 to 10 lb. of water per pound of coal from and at 212 deg. F., or the equivalent, they may be regarded as doing fairly well. If not, the conditions of the firing, of the boiler settings and of the boilers themselves should be examined and improved where needful.

CO_2 Specific Heat—What is the specific heat of carbonic-acid gas?

J. B.

This is not a constant quantity, but varies with the pressure and volume. The figures obtained by different investigators do not agree. The latest edition of "Experimental Engineering," by Carpenter & Diederichs, gives the values by G. Upton, who also plotted curves of average values, according to which the mean specific heats at constant pressure and at constant volume are as follows:

Deg. F.	Constant Pressure	Constant Volume
0	0.2	0.155
400	0.215	0.170
1000	0.235	0.190
2000	0.260	0.215
2500	0.270	0.225

Properties of Steam—Is there any rule for calculating the temperature and relative volume of steam from a given pressure?

E. S.

Regnault, the French physicist, made numerous and careful experiments to determine the relations of pressure, temperature and volume of steam and a number of able scientists have been over the same ground since. Very complicated empirical formulas have been constructed of the properties of steam and these have been corrected and recorrected graphically. Many textbooks on steam give these formulas. The ones now regarded as most exact are to be found in Marks and Davis "Steam Tables and Diagrams." The use of the formulas is so cumbersome that it is universally the custom to use tables of these properties instead of carrying out independent calculations.

Condensing or Noncondensing Operation—We have a 16x36-in. Corliss engine driving a 150-kw. generator. It operates under light load 18 hr. and normal load 6 hr. Would it probably pay to operate condensing?

J. S. H.

Ordinarily it does not pay to install condensing equipment in a plant containing only one engine and that a small one, for the exhaust steam can likely all be used for heating feed water. During the peak load about 20 per cent. would be saved if the engine exhausted into a 26-in. vacuum. The light load during three-fourths of the time calls for early cutoff and a condenser might effect no saving during this time, as the cylinder cooling through a great range of expansion in a single cylinder will bring about two much initial condensaton. Reducing the initial pressure during this time and with a vacuum of 26 in., there might be 20 per cent. saving in steam consumption. Whether or not it will pay to install condensing equipment will depend very largely on the cost of cooling water in any given locality. The net economy will be determined by estimating from the cost of the equipment, interest on the investment, depreciation, and the cost of operation. Against this place saving in decreased fuel consumption and reduced cost of labor (if any). If there is a difference in favor of condensing it will pay to make the change unless there is a need of the exhaust steam for heating purposes. In the latter case there is seldom any advantage in operating condensing.

ENGINEERS' STUDY COURSE

Principles of Combustion—III

Combining Weights of Elements

Whenever a chemical action, such as combustion, takes place, the elements or compounds always combine in fixed proportions by weight. Because of this fact we are able to use Col. 3 in Table I, which gives the combining weights of the various elements. Whenever two or more elements combine they do so either in direct proportion to the numbers shown in Col. 3 or in some multiple of those numbers. The exact manner in which they combine is shown by the formulas in Col. 4. Thus, when carbon combines with other elements it always combines in weights of 12 or some multiple of 12, such as 24, 36, 48, etc., depending on the formula. When oxygen combines it does so in weights of 16 or multiples of 16. And so with all other elements, they combine according to their combining weights or atomic weights as the chemist usually calls them.

Combustion of Carbon

Carbon has two ways of combining with oxygen. One is called complete combustion and the other incomplete combustion. Whether combustion is complete or incomplete depends upon conditions. If sufficient air is supplied to every particle of the carbon, combustion will be complete; if not, some of the carbon will be only partially burned.

Taking up incomplete combustion first, the formula in Col. 4 is

$$C + O = CO$$

This means that the carbon combines with the oxygen in the proportion by weight of 12 to 16, because those are the combining weights of the two elements. This reduces to 1 to $1\frac{1}{3}$. Hence, for every pound of carbon incompletely burned $1\frac{1}{3}$ lb. of oxygen are required. If 27 lb. of carbon were incompletely burned the amount of oxygen used would be 36 lb., because the proportion of 27 to 36 is the same as 12 to 16 or 1 to $1\frac{1}{3}$. The figuring is just the same for all other quantities of carbon no matter whether the amount is a fraction of an ounce or thousands of tons.

The product of the incomplete combustion of carbon is a gas called carbon monoxide and its chemical symbol is CO.

The name monoxide is one of those built-up words from mono, meaning one or one part, and oxide, meaning the chemical union of oxygen with some other substance. Thus, carbon monoxide means one part of oxygen united with carbon. When the number of parts of the other element is not stated it is always taken as one. Hence, the exact meaning of carbon monoxide is one part of carbon united with one part of oxygen.

To calculate the amount in pounds of the CO formed it is only necessary to add the weight of the carbon burned and the weight of the oxygen required according to the formula; the result is the weight of the carbon monoxide. What the volume of this gas is depends upon the temperature as has been explained.

Thus, if 5 lb. of carbon are incompletely burned the weight of CO formed is

Weight of carbon	5 lb.
Weight of oxygen required 5x1⅓	6⅔ lb
Weight of carbon monoxide formed	11⅔ lb.

This carbon monoxide is a combustible gas and if supplied with air so that it can unite with the required amount of oxygen it will burn when heated to its temperature of ignition. Its formula is

$$CO + O = CO_2$$

This means that the CO or carbon monoxide combines with oxygen in the proportion of

$$C + O \text{ to } O$$
$$12 + 16 \text{ to } 16 = 28 \text{ to } 16$$

or 1 to $\frac{16}{28}$, which equals 1 to $\frac{4}{7}$. Thus, for every pound of CO burned $\frac{4}{7}$ of a pound of oxygen is required.

The product of the combustion of CO is a gas called carbon dioxide, which has the chemical symbol CO_2.

The name dioxide is built up in a manner similar to monoxide, the prefix di meaning two or two parts. Thus, carbon dioxide means one part of carbon combined with two parts of oxygen. By "parts" it must be remembered we mean "chemical parts," i.e., combining weights as shown in Table I and explained before. The weight of CO_2 formed by the combustion of CO is found by adding the weight of CO burned to the amount of oxygen required according to the formula. Thus, if 6 lb. of CO were burned to CO_2 the weight of CO_2 formed would be

TABLE I. COMBUSTION DATA

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8
Name of Element	Symbol of Element	Combining Weight	Combustion Formula	Compound Formed	Heat Liberated B.t.u. per lb. of Combustible	Pounds of Oxygen Required per lb. of Combustible	Pounds of Air Required per lb. of Combustible
Carbon	C	12	$C+O=CO$	Carbon Monoxide (Incomplete Combustion)	4,450	1⅓	5.76
			$C+2O=CO_2$	Carbon Dioxide (Complete Combustion)	14,600	2⅔	11.52
			$CO+O=CO_2$	Carbon Dioxide	4,350*	⅔	2.47
Hydrogen	H	1	$2H+O=H_2O$	Water	62,000	8	34.56
Sulphur	S	32	$S+2O=SO_2$ $S+3O=SO_3$	Sulphur Dioxide Sulphur Trioxide			
Oxygen	O	16	.....	.....			
Nitrogen	N	14	.....	.....			

*This figure is correct and replaces the 10,150 given in the Apr. 22 issue.

Weight of CO burned	6 lb.
Weight of oxygen required $6 \times \frac{4}{7}$	$3\frac{3}{7}$ lb.
Weight of carbon dioxide formed	$9\frac{3}{7}$ lb

If sufficient air is supplied in the first place so that each particle of carbon can unite with all the oxygen it desires, complete combustion results, the formula for which follows:

$$C + 2\ O = CO_2$$

This means that the carbon unites with the oxygen in the proportion of

$$C + 2\ O = CO_2$$
$$12 + 2\ (16) = 44$$

producing $\frac{44}{12} = 3\frac{2}{3}$ lb. of CO_2 for every pound of carbon burned. Every pound of carbon when completely burned requires $\frac{32}{12} = 2\frac{2}{3}$ lb. of oxygen.

Combustion of Hydrogen

When carbon is burned, part of it may be burned completely to form CO_2 and the rest may be only partly burned to form CO. This is not true of hydrogen. The hydrogen either burns completely or not at all. Thus, if not enough air is supplied for a given quantity of hydrogen, part of the hydrogen (enough to use up all the oxygen in the air supplied) burns completely and the balance does not burn at all.

The formula for the combustion of hydrogen is

$$2\ H + O = H_2O$$

According to Table I, Col. 3, the combining weight of hydrogen is 1, that of oxygen 16, the same as in all other cases. Thus, substituting in the formula, we have

$$2\ H + O = H_2O$$
$$2\ (1) + 16 = 18$$

It requires then $\frac{16}{2} = 8$ lb. of oxygen for the complete combustion of every pound of hydrogen burned, and the weight of the product formed is $\frac{18}{2} = 9$ lb.

The product formed by the combustion of hydrogen is water (H_2O) in the shape of highly superheated steam. This steam can be condensed just the same as steam made directly from water can be condensed back into water again.

Sulphur burns with oxygen and forms SO_2 in much the same way that carbon burns to form CO_2. The formula is

$$S + 2\ O = SO_2$$
$$32 + 2\ (16) = 64$$

From this it will be seen that

$$\frac{32}{32} = 1\ lb.$$

of oxygen is required for the combustion of every pound of sulphur and that

$$\frac{64}{32} = 2\ lb.$$

of sulphur dioxide are formed.

Sulphur will also combine according to this formula

$$S + 3\ O = SO_3$$

Here ½ lb. more of oxygen is required for combustion. These products (SO_2 and SO_3) easily combine with water and form sulphurous and sulphuric acid as follows:

$$SO_2 + H_2O = H_2SO_3$$
$$SO_3 + H_2O = H_2SO_4$$

These acids strongly attack iron and hence do injury to flues and chimneys made of that material.

As pointed out previously, the heat value of sulphur is so low and the percentage of sulphur found in the average grade of coal is so small that we can easily afford to neglect it completely in our calculations.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Bad case of an engine running away (from the owner) happened near Pittsburgh recently. Footprints in the snow showed that the operators had loaded the 600-lb. engine into a wagon and skipped with it. Must be trying to prejudice the owner against the isolated plant.

⁂

You should eat more onions, advises the Department of Agriculture, thus reducing the cost of eats. It will also tell you where you can locate a supply cheap. It needs no Burns to find the whereabouts of the average healthy onion; it speaks for itself. A hunk of rye bread, a rosy-cheeked Bermuda, a Ponderosa and a can of suds are nourishing some of our hardest-working citizens.

⁂

Next time you are under the knife, insist on getting old Doc. Greene's automatic metal rivet, and take no other. These rivets can be applied to the edges of the wound, and instead of the old stitching, can be laced or unlaced to suit the convenience—of the doctor. May be a shop kink in the use of the stay-bolt, if Doc. finds his way to experiment with it.

⁂

"Gas Review" has an article written by Clam on gasoline engines. Can our old French friend, Colonel De Paty du Clam, have forsaken the nine gods of war to follow a peaceful trade? Us technical papers will spend any amount of money to get the best there is. Anybody here know Clam?

⁂

Folks to home have always reckoned that the Vice-President was merely a bench-warmer, just couldn't get into the game unless the Big Pitcher was taken out of the box. Not so with T. Riley Marshall; he's one lively little man, and a rooter from Rootersville. "Baseball diamond dirt is clean dirt," says T. Riley, "and that's more than a Democrat can say for all the diamonds in America."

⁂

"When one gets to love work, his life is a happy one," says Ruskin. Are you ready for the question? Those in favor—(delegate wakes up in time to shout "i"; thinks he's voting for the 8-hr. law). Contrary minded: NO! The "noes" have it by 976 to 1. Move we adjourn!

⁂

The proposed tariff may help a bit. On meats it calls for a 50 per cent. reduction; dead poultry (no time limit given) 30, and prunes 50; very little was squeezed out of lemons, and butter and cheese are still going strong; beans and cream and pickles and honey come down some; also mushrooms and cider and grapes and pork; also oranges and tallow; starch stays pretty stiff. Buckwheat and shoe machinery go on the free list. Some of these foodstuffs are high yet to our way of thinking, but you can't handle a tariff bill too carefully, even if it never passes.

⁂

The fillums now include steam as a fitting subject for both interest and education. A photoplay has been written around the early struggles of Watt and Stephenson. Undoubtedly there is a future for popular science in the movies.

⁂

"It is easier to live on $15 a week than on $15,000 a year," says a writer. Without the Missouri test, this is bunk. Will some power-plant fireman kindly step up on the platform and tell the audience what he thinks about it? This way, please.

⁂

"When excessive water ram occurs in riveted-steel pipe, the riveted joints open up slightly by a momentary stretching of the rivets, or yield in other parts, within the elastic limit, and allow water to escape from the joints. If the excess pressure is not too great and too long continued, the pipe comes back to its original size, and is as tight as before."—New England Water Works Association Proceedings, Vol. 25, page 39.

Why not use these "elastic" rivets in horizontal return tubular-boiler construction and thus make every boiler its own safety valve?

Power Matters in Textile Mills*

By F. W. Dean

SYNOPSIS—The turbine vs. the reciprocating engine, fire-tube vs. water-tube boilers and purchased power vs. a plant at the mill.

The question constantly arises as to whether it is best to purchase turbines or reciprocating engines. This must depend upon the original costs, the space occupied, the relative economies when new, the maintenance of economy after operation begins, the reliability and the repairs.

Initial Cost and Floor Space

In Table 1 are given prices to be expected at this time of several units of each kind of prime mover. These are for sizes in which the kilowatts are real outputs at 80 per cent. power factor.

TABLE I. COSTS OF AND SPACE OCCUPIED BY VARIOUS SIZES OF RECIPROCATING ENGINES AND TURBINES WITH CONDENSING APPARATUS AND EXCITERS, ALL ERECTED, INCLUDING FOUNDATIONS

(Capacities given in real outputs)

Capacities Kw.	Horizontal-4-Valve Engines	Horizontal Turbines	Space Occupied Engines	Space Occupied Turbines
500	$22,700	$12,250	18x26 ft.	14x6 ft.
1000	40,200	17,900	24x30 ft.	14x8 ft.
1500	62,200	23,800	26x35 ft.	19x9 ft.
2000	76,400	30,500	28x37 ft.	21x9 ft.

From this table it is evident that the comparison is wholly in favor of the turbine. The relative economies to be expected from the two types are given in Table 2.

TABLE 2. STEAM CONSUMED PER KILOWATT-HOUR, PRESSURE 150 LB.

	Engine		Turbine
Capacities, Kw.	Saturated Steam Guaranteed per Kw.-hr., lb.	Superheat 100 Deg. F. Guaranteed per Kw.-hr., lb.	Superheat 100 Deg. F. Guaranteed per Kw.-hr., lb.
500	18.67	16.8	17.7
1000	18.80	16.9	18.0
1500	18.80	16.9	16.8
2000	18.93	17.0	16.6
	Vacuum 26 in.		Vacuum 28 in.

Apparently there is little to choose in the economy of one type of prime mover over the other. It is said that an experimental turbine of 10,000 kw. capacity has been tested that used 12.95 lb. of steam, superheated 100 deg. F., per kilowatt-hour and there is every probability that the turbine will be improved.

Maintenance

Concerning the maintenance of economy it is well known that the best reciprocating engines, with either Corliss gridiron or poppet valves, maintain their economy for years, and that the blades or buckets of turbines have been eroded by the steam as it passes over them. There are instances of this erosion being sufficient to make the replacement of blades necessary, as there was a great falling off in economy. Blades have eroded so rapidly in some cases that it has been necessary to replace a set at a cost of several thousand dollars in five years. It appears to depend largely upon the material of which the blades are made, and improvements in this respect have been made and are being made. Turbines are not stripping blades nowadays as they did a few years ago. Repairs in other respects than this are slight, much less, in fact, than with piston engines, and in many cases no blade replacements have been needed.

*Abstract of a paper read before the National Association of Cotton Manufacturers, Boston, Apr. 24.

High Vacuum for Engines Desirable

Turbines are always provided with condensing apparatus of sufficient capacity to give a vacuum of at least 28 in. It is assumed by all operating engineers that a vacuum of anywhere from 23 to 27 in. is desirable for a reciprocating engine, the reason being that there is more economy in obtaining feed water from the condenser discharge with the higher temperature, due to a poor vacuum, than there is with the lower, due to a high vacuum. This belief may have had some truth in the days when the air and feed pumps were worked from the main engine, and when separate steam-driven auxiliaries were not used, the exhausts of which are now used for heating feed water, and when also other means of heating boiler feed were not known or used.

At the present time this idea is a mistake. It will always be found that a condensing engine with a high vacuum is more economical than one with a low vacuum, not only in steam consumption, but in coal consumption, especially when the feed water is not taken from the condenser discharge. The other belief seems to be world wide, and apparently has been handed down from the distant past.

The turbine is usually given the benefit of superheated steam, but it appears to be claimed both by turbine and engine builders that about 1 per cent. of steam is saved for each 10 deg. F. of superheat.

It should not be overlooked that the most economical steam engine is the noncondensing engine, the exhaust steam of which is utilized, and in this application the turbine shares. It is not as economical when noncondensing as the engine. In other words, it produces more exhaust steam for the same power, but if this is all utilized it makes no difference. The turbine also shares with the compound engine the opportunity to draw steam for manufacturing purposes between the expansion stages.

There is an important application of the turbine that is not shared by the piston engine. This is the exhaust-steam turbine. While the economy of the piston engine would be improved by a high vacuum, recently low-pressure turbines have been placed between the low-pressure cylinder and the condenser, simultaneously with an improvement in the vacuum. The turbine lends itself to this application better than a piston engine, for to obtain a similar result with the engine, an enormous low-pressure cylinder would be required. Low-pressure turbines can operate with the collected exhausts of any number, kind and size of engines, and high economy is sure to result. Moreover, the mixed-pressure turbine will be automatically supplied with live steam as the supply of exhaust steam diminishes or fails.

Steam turbines practically cannot be applied to direct-current generators unless they are geared so that the generator speed is reduced to diminish commutator difficulties. While turbines for direct-current generators are made, the contemplation of a turbine presupposes, ordinarily, alternating current. Further, the adoption of a turbine carries with it the use of electricity in driving shafting or machines directly, that is, in groups or individually as the case demands.

Belt, Rope and Electric Drives

If a mill permits the application of a piston engine with simple straight belt or rope drives, this is a more efficient method of driving than by electricity. If the drives are indirect the friction load may be as much as 40 to 50 per cent., and electricity is the more efficient.

There are advantages in electrical driving, among which may be mentioned smaller space occupied by the prime mover, absence of a belt tower, head shafts, pulleys and belts or ropes, any amount of subdivision of drives with the resulting opportunity of shutting down groups of machinery, the application of motors to separate machines, and the measurement of the power which a motor gives out. It is said that efficient variable-speed motors will soon be in the market, and these will be a convenience.

In the above advantages that of an increased output by electrically driven machinery is not included. It is possible to understand how machines driven by electric motors can go either faster or steadier than those driven by belts. If there has been an increase in product in any case it must have been due to removable defects of the original drive. It is evident that this must be so in an extended group drive, for there is little or no diminution in the number of belts used. It would, therefore, only be in individual drives that the increase would exist and here there is no reason why the belt cannot do whatever the motor can.

In general, the advantages of electricity are such that it is probable it will be used universally in the early future for driving textile mills. One reason, not thus far mentioned, is that it permits a central steam plant to be used under all circumstances, and this adds to efficiency and minimum charges of all kinds, especially in an overgrown mill having several steam plants. A further consideration of the matter leads to the inevitable conclusion that prime movers in textile mills will be steam turbines operated by superheated steam of rather high pressure. The economy of turbines is increasing and is likely to surpass that of piston engines.

In bad-water districts the fact that turbines use no oil in the working steam is a great advantage, for with surface condensers the pure water from the condensed steam can be used in the boilers and thus avoid the boiler troubles that come from bad water.

The Boiler Plant

Fire-tube boilers, either vertical or horizontal return tubular, are cheaper to build, are more economical, more easily cleaned, and safer than water-tube boilers. To the writer's knowledge no horizontal return-tubular boiler built with butt joints has exploded, nor has any straight or conical-shell vertical boiler with such joints exploded. There have been many disastrous explosions of water-tube boilers.

Water-tube boilers have tubes expanded into drums, and have in these drums structures in unstable form likely to change shape with variations in temperature. This causes the plates to bend back and forth in the weakest place, thus causing a likelihood of rupture in the same manner as in the case of shells with lap joints. Water-tube boilers have from two to four drums, and each one of these is more likely to explode from the effects of distortion than the well balanced shell of a horizontal or vertical fire-tube boiler.

The economy of the fire-tube type is greater than of the water-tube, because the tubes can be kept cleaner, because they are as clean on the fire sides when old as when new, because they do not short-circuit, and because they are not partially covered up by baffle tiles. Another important reason for greater economy is that water-tube boilers have several doors and clean-out holes in the brickwork, and these leak air, especially after the boilers have been in use some time. This cools the gases, reduces the economy of the boiler and also that of the economizer if one is used.

Concerning the safety of fire-tube boilers, the butt joint has done much, but such joints with the outside covering plate narrower than the inside are not ideal, and boilermakers should abandon them and use covering plates of equal widths.

In large mills the use of large boilers, say of 400 or 500 hp. instead of 150 to 200 hp., should be encouraged. The large boilers are just as safe, slightly more economical, take up less room, reduce the number of steam pipes, blowoff pipes, stop valves, blowoff valves, feed valves, water columns, steam gages, and reduce the amount of brickwork and pipe covering.

The use of stronger draft and more rapid combustion, with the object of reducing the number of boilers and firemen is to be encouraged, as the number of boilers in some mills is absurdly large. Coal can be properly burned at a rapid rate as at a slow rate. It is merely a question of adaptation of the method of firing, and firemen can be as well schooled to fire for rapid combustion as for slow.

Purchased Power

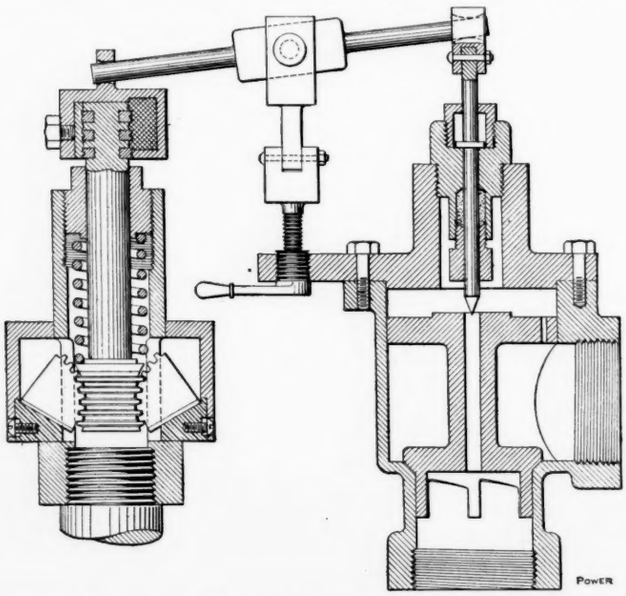
The outside central-station companies are making active efforts to sell electric power to textile mills as well as to mills and factories of other kinds. The price is given at so much per kilowatt-hour at the mill switchboard. They are especially anxious to do this because it keeps a plant the size of which is determined by the night-lighting requirements, from earning next to nothing during the daytime and they consequently are able to make low prices. Comparing the cost of producing power in mills with the cost of purchased power, the author has invariably found that it is advantageous for the mill to produce its own power. In textile mills it is more advantageous than in most other kinds, as the plants are usually of considerable size and adapted to the most economical production of power, due to their size and uniformity of load. This is particularly the case in mills where considerable steam is used, and, especially where exhaust steam can be used as for dyeing, to say nothing of slashing and heating. In such mills there is no chance for purchased power, and in mills where steam is used for power and heating only, every means for low cost of power which the public station can use is available to the mill with a probability of more care being taken in operation.

In factories where the power required is intermittent, and the shafting friction large, as in a boiler shop, purchased electric power is advisable, unless electricity is generated in some other part of the plant for other purposes. In either case electric individual driving is advisable.

The balance of the paper was devoted to an analysis of a circular giving the cost of power as produced by the Fitchburg Yarn Co. This was given as $16.68 per indicated horsepower per year. The analysis by Mr. Dean showed that a reduction to $15.10 would be possible.

Clark Centrifugal Governor

A compact form of governor for steam or hydraulic work has been designed by C. H. Clark, of New York City. Its action depends on the centrifugal force of a pair of sectors working against a spring. The construction is shown in the accompanying drawing. The edges of the sectors pivot in the lower corners of a casing surrounding the governor spindle. The proportions are such that the fulcrum is 2½ times farther from the center line of the spindle than from the center of gravity of the weights. The teeth of the arcs mesh with a rack at the base of the spindle. As the governor revolves, the



SECTIONAL VIEW OF GOVERNOR AND VALVE

weights tend to turn out and thus raise the governor spindle against the downward pressure of the spring. The upward push of the sectors increases with the speed of the governor in practically a straight line up to a displacement of nearly 80 deg., as does the pressure of the opposing spring. The construction limits the displacement to 45 deg. A balance between the two forces is thus readily effected and regulation within ½ of 1 per cent. from no load to full load is obtained.

The movement of the governor spindle controls a throttle valve by means of a pin designed to fit an opening through the valve body. The upper face of the valve has twice the area of the lower face. When the pin closes the opening, steam admitted through the small hole at the side, in the upper disk, builds up in pressure and forces the valve to its seat. As the pin recedes from the opening the steam above the disk escapes to the discharge side of the valve, and allows the upward pressure, which is now in excess, to open the valve. As a matter of fact, the valve floats on the line, following closely the movement of the pin. The two do not come in contact, but as a precautionary measure, the opening is made a shade larger than the diameter of the pin so that there can be no interference with the action of the governor.

For a quick-opening throttle or hand operation of large steam and water valves this same construction is recommended and has been applied in some cases by the inventor.

Standards for Ventilation Legislation

The report of the committee appointed by the American Society of Heating and Ventilating Engineers last year to formulate standards for ventilation legislation for motion-picture show places, and presented at the last annual meeting of the society in New York City, has just been approved by a mail ballot of the members. The report has been printed and is being distributed among the members.

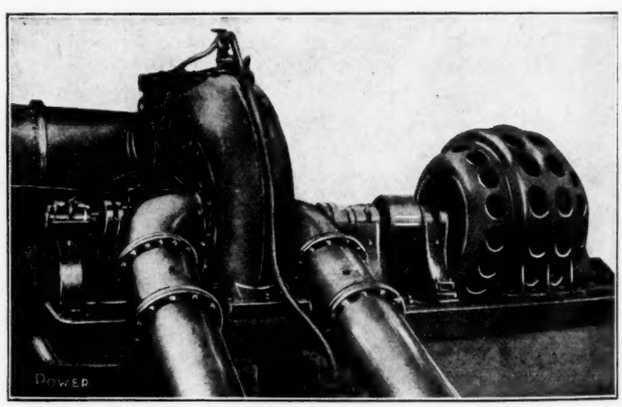
The society has on hand a generous supply of this report in printed form at its headquarters, 29 West Thirty-ninth St., New York City, and will be glad to furnish free copies to all engineers, boards of health, town councils, ventilation inspectors and others interested in the subject of proper ventilation of motion-picture show places.

Modern Pumping Units for Steel Mills

BY C. A. TUPPER

In the accompanying illustration is shown a very good example of the modern motor-driven centrifugal pumps, for handling large volumes of water daily, which are being installed by large industrial establishments throughout the country. This unit was built for a steel mill.

The pump, which has a snail-shell casing, is of the single-stage, double-suction type. Its working head is about 125 ft. Operating at normal speed, it will deliver



LARGE MOTOR-DRIVEN PUMP

25,000,000 gal. of water during 24 hours' continuous service, and if speeded up its capacity is considerably greater. On test this approached 30,000,000 gal. The operation of the entire unit is exceptionally smooth, all end-thrust being eliminated by an arrangement in the design which admits water from both sides, directly opposite the center of the revolving impeller, thus creating a balanced suction.

The efficiency of such a pump is dependent largely upon the velocity imparted by centrifugal force and the extent to which the kinetic energy can be converted into pressure as the water leaves the impeller, its force being the greatest at that instant. Accordingly, the most important improvements in the designing of large centrifugal pumps, both in the United States and abroad, have been in the shaping and arrangement of fixed dif-

fusion vanes to so guide the water that its velocity, as it leaves the impeller, is converted into the maximum of pressure with the least possible disturbance to its flow.

In the pump illustrated, the provision made for this is in line with the latest tendencies of American and European designs, although German engineers are working on a similar unit having movable diffusors.

It is interesting to note that, while the impeller shaft was made from an openhearth steel forging, it was decided, with the quiet operation, that the casing, impeller, etc., could be of a good grade of close-grain cast iron.

The motor driving this pump is of the wound-rotor induction type, which permits of variable speed. This is particularly important for starting. It operates on three-phase, 25-cycle current, at a potential of 440 volts, and normally develops 750 hp., with large overload capacity.

Marine Engineers' Dinner

Over 200 attended the eighteenth annual dinner of the Marine Engineers' Beneficial Association, No. 33, at the Broadway Central Hotel, New York City, April 23, 1913. National President William F. Yates presided as toastmaster and after a few words of welcome introduced Thomas McGill, secretary to the new dock commissioner, the Hon. R. C. H. Smith. In behalf of the commissioner, Mr. McGill told something of the aims and plans of the Commission, particularly with respect to the improvements in the dockage facilities for the Trans-Atlantic liners.

The remainder of the evening's entertainment was in the form of song and story, a very interesting program having been arranged by Frank Martin. Among those who entertained were the Dixie female quartet, Herbert Self, Jack Armour, Billy Murray, Jim Devins, Joe McKenna and Miguel O'Connell.

A 19x21 Lentz engine is said to have made a record of 16 lb. of steam per indicated horsepower-hour upon the testing floor of the Erie City Iron Works, its builders. The initial pressure was 125-lb. gage, superheat 200 degrees and the exhaust into the atmosphere.

To Reorganize Northern Colorado Power Co.

The plan of reorganization of the Northern Colorado Power Co., which was offered by Vice-President Chambers of the Electric Properties of New York, to the executive committee of Denver stockholders' association and which calls for a reduction of bonded indebtedness and reissuance of new stock for that now outstanding, is reported to have been rejected by the Denver committee.

It was stated, however, that Mr. Chambers had two other plans of reorganization to offer at the stockholders' annual meeting on April 24. Under the plan that was submitted the bonds would be reduced from $2,500,000 to $2,000,000, and to compensate the bondholders for this reduction they would receive new common stock to the amount of 20 per cent. of their holdings. The new stock issue will be the same as at present—$1,000,000 6 per cent. preferred and $2,000,000 common.

Central States N. A. S. E. Conventions

The Central States Exhibitors Association will have charge of the exhibit at one more state N. A. S. E. convention this year, Ohio being the additional one.

Following are the convention cities, dates, official headquarters, hotels and hotel rates:

Kentucky, Hopkinsville, May, 7, 8, 9, Hotel Latham, American plan $2 to $3 per day.

Missouri, Springfield, May, 14, 15, 16, Metropolitan Hotel, American plan, $1 up per day.

Iowa, Burlington, May 21, 22, 23, Hotel Burlington, European plan, $1.50 to $3 per day.

Illinois, Rockford, May, 28, 29, 30, The Nelson Hotel, American plan, $2.50 up per day.

BANQUET OF THE MARINE ENGINEERS' BENEFICIAL ASSOCIATION NO. 33, IN NEW YORK, APR. 23, 1913

Indiana, Terre Haute, June, 4, 5, 6, Terre Haute House, American plan, $3 up per day.

Ohio, Toledo, June, 11, 12, 13, Boody House, European plan, $1.50 up per day.

Michigan, Grand Rapids, June, 18, 19, 20, Hotel Pantlind, European plan, $1.50 up per day.

Wisconsin, Milwaukee, July, 9, 10, 11, Republican House, American plan, $2.50 up and European plan, $1.50 up per day.

Minnesota, Duluth, July, 16, 17, 18, Hotel Spaulding, European plan, $1 up per day.

Difficulties of Running a Power Plant

I. E. Moultrop, the mechanical engineer of the Edison electrical plant, gave an informal talk before the Massachusetts Institute of Technology student branch of the American Society of Mechanical Engineers. His subject was "The Difficulties of Running a Power Plant," which he selected for the especial benefit of the seniors, who are now making a power-plant design.

Some of the points taken up were the difficulties of boiler setting, uses of the economizer, condensers, mechanical stokers, automatic conveyors for coal and ashes, and steam piping. Mr. Moultrop said that economizers should not be used without a fan. They are also of no use in small plants where the load is variable, but are especially well adapted to large plants where the load is steady. He also took up the advantages and disadvantages of mechanical stokers. With good apparatus it is possible for one man to tend from four to eight boilers. The saving made in this way is enough to offset the overhead expense.

The talk was very informal, being more like a conference than a lecture. Many questions were asked, and everything was explained with much clearness. The speaker was a man of great personality, the ideal engineer, and the members of the society all felt that they had benefited greatly from the talk.—"Tech."

Experience for Seattle Students

An example of the very practical nature of the power-plant engineering courses of the Seattle Engineering School is given by the following incident:

The Tacoma-Roche Harbor Lime Co.'s vessel, the "Archer," had been tied up for a number of days because its 300-hp. gas engine, operating with a producer-gas plant which, at the time it was installed a few years ago was claimed to be the largest producer gas plant in the world and is now the largest on the Pacific Coast, was badly out of order, owing to the difficulty in securing competent men to operate it and keep it in working condition.

Responding to the request of the president of the lime company, the school sent its gas engineer and a crew of advanced students in gas engineering to the "Archer." They overhauled the producer plant and engine, found the troubles and corrected them, and soon put the vessel into commission.

Incidentally, one of the students who assisted in the work was employed by the lime company to operate the "Archer's" gas producer, and he is now regularly with the ship. This also shows the great need of competent, trained gas engineers on Puget Sound.

Report Regarding Keokuk Plant False

A New York newspaper recently announced that work had stopped on the Keokuk hydroelectric plant, though the project was but half completed. The report states that only 150,000 hp. will be generated instead of the 300,000 hp. as planned, intimating that the whole development was to be carried out immediately but that lack of financial support has necessitated cutting the installation in half.

Those who have followed the project know that the intention from the start has been to develop only 120,000 hp. at present, and that expansion was not to come for some years. Moreover, all of the concrete has been in for some time, the [illegible]ure is completed, the turbines and electrical machinery are [illegible]ractically all in place, and the transmission line to St. Louis is finished.

The report, therefore, is manifestly erroneous. Moreover, the New York office of Stone & Webster denies that there has been any cessation of work or embarrassment in funds.

SOCIETY NOTES

The New England Society of Superintending Engineers held its regular monthly meeting and dinner on the evening of Apr. 26 at the American House, Boston. Several prominent engineers were admitted to membership. A very interesting talk was given by F. L. Fairbanks on the construction of boilers, after which there was a general discussion of the subject.

The American Order of Steam Engineers will hold its twenty-seventh annual convention in the Parkway Building, Broad St., Philadelphia, on June 2 to 7. The Windsor Hotel will be the association headquarters. The local committee and that of the American Supply Men's Association have their arrangements almost completed, and declare that this convention will prove a highly affair.

At the semi-monthly meeting of the Detroit Engineering Society on the evening of May 2, Clarence W. Hubbell, chief engineer of the Bureau of Public Works, Manila, P. I., delivered an interesting informal talk on "Public Works in the Philippine Islands." Mr. Hubbell is a member and former secretary of the society and has been identified with the public works of the Philippine Islands for several years.

OBITUARY

E. M. ADAMS

E. M. Adams, president of the Ohio Society of Mechanical, Electrical and Steam Engineers, and for a number of years chief engineer of the Quaker Oats plant at Akron, Ohio, died suddenly of diabetes on Apr. 17.

JAMES TANGYE

James Tangye, one of the Tangye brothers so well known in English mechanical circles, died at his home in Cornwall, on Apr. 4, aged 88 years. While each of the brothers, of whom George Tangye is the survivor, did his share to build up the well known firm of Tangyes, Ltd., it is generally accepted that James' work and influence were foremost up to the time of his retirement from active work in 1872, while still a comparatively young man.

Possibly James Tangye's application of the principles of hydraulics, his earliest introduction to which was in connection with Brunel's testing machine, was among his most important labors, at all events as regards the fortunes of his firm.

His introduction of the portable hydraulic jack caused an immense stir in engineering circles at the time and brought about a revolution in manufacturing methods. As pointed out by "The Engineer," it is a curious fact that this appliance as it came from his pencil has remained very nearly unaltered until the present day. James Tangye also applied the principle of his jack to a number of other purposes, and designed a series of handy tools for punching, shearing and otherwise manipulating iron by hand, as well as special presses for a variety of uses.

James, at the suggestion of his brother, also got out the drawings for a series of steam engines of different powers which could be made to standard. This was an entirely novel departure, all engines having previously been made one by one and without any reference to interchangeability of parts. Of these drawings it is stated that, like all that ever proceeded from his hands, the design was produced once for all, and needed no retouching or modification as long as the conditions for which it was intended remained unaltered. In these engines the overhanging cylinder, the crank plate and the form of connecting rod were all innovations. The engine was an advance on anything of the kind previously introduced. The high-speed governor was also more delicate and efficient than any of its predecessors. Having designed the series of engines, James set himself to evolve improved methods of manufacture, and the introduction of jigs is attributed to him.

PERSONALS

Thomas G. Oakes, recently connected with the New York office of the Nelson Valve Co., is now associated with the Shipley Construction & Supply Co., New York City.

A. Richard Foley, of the Home Rubber Co., sailed for England on the "Mauritania" an Apr. 23. Mr. Foley will assume the management of that company's London office.

J. H. Stretton recently resigned as chief engineer of the Baltimore Hotel, Los Angeles, Calif., to accept the position as chief engineer of the W. H. Constable Co.'s warehouse and cold storage plant at El Paso, Texas.

E. F. Putnam, formerly sales engineer with the Edison lamp department of the General Electric Co., has been appointed commercial manager of the United Electric Light & Water Co., Greenwich, Conn. Mr. Putnam has also been connected with the Public Service Electric Co., at Camden and Newark, N. J.